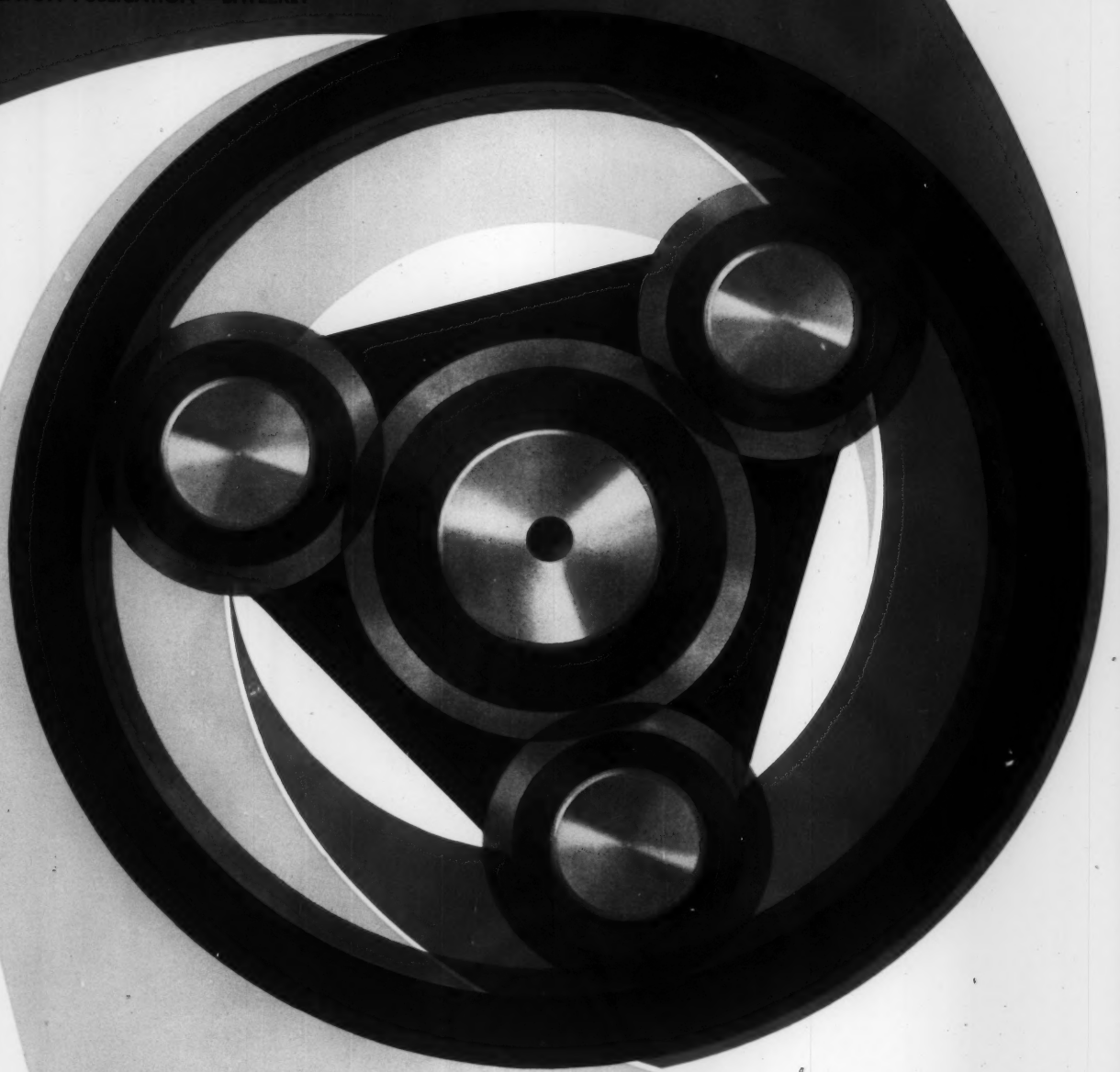
AUGUST 21, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Planetary Gears

Contents, Page 3

FARNSWORTH

S.S.White

FLEXIBLE SHAFTS

are the answer

where simplicity is the aim

Simplicity in Use — Selecting an S.S.WHITE Flexible Shaft and applying it to any remote control or power-drive application is a quick, easy job. S.S.WHITE has reduced flexible shaft selection to a relatively simple task through the use of standard flexible shaft combinations, clear-cut, quick reference selection tables and expert engineering and technical advice.

Simplicity in Design — Because an S.S.WHITE Flexible Shaft takes power or control around turns and obstacles — eliminates excessive parts — you save space and weight . . . and help improve product efficiency. A typical example is the torque converter governor drive shown. Here the shaft drives the governor from the transmission with a minimum of parts . . . simplifies installation problems, too!

Consider S.S.WHITE Flexible Shafts for driving or controlling parts in your own equipment. We'll be glad to help you work out any application problems you may have. Write, wire or call.

S.S.White

THE NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

S.S.White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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What! Painting or Etching to Suit the Occasion!

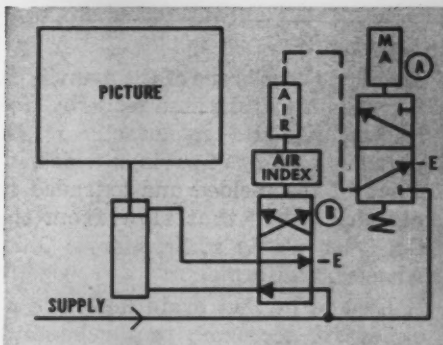
This "one knob picture control" is unlikely we will agree, but . . .

Art tastes do vary. The boys may not wish to share theirs with the spouses . . . in fact they may not *dare* to. And it might even call for a quick disappearing act for the little lady who is wearing little more than a blush. Unlikely as this device is, it would efficiently accomplish this neat scene change for such "art lovers." In the meantime, it gives us a chance to show something new. How one valve can now extend a double acting cylinder, letting it remain extended when the valve is released, then retract the cylinder at the next actuation by using the new Ross momentary air index adaptor.

The Ross air indexing momentary has hundreds of serious uses

Now, a standard Ross Skyline valve, either solenoid or air operated can include this momentary air index adaptor. Then the first actuation will send the valve one way and it will stay in that position, even when the actuator releases. The next stroke reverses the valve, again it stays after actuator release, etc.

See your Ross representative for application information.



SEQUENCE OF OPERATION

1. Valve (A) is manually actuated, valve (B) reverses and stays put, keeping pressure on one side of double-acting cylinder.
2. When Valve (A) is manually actuated again, valve (B) reverses and stays put, keeping pressure on opposite side of double-acting cylinder.

Ross OPERATING VALVE CO.

109 East Golden Gate • Detroit 3, Michigan

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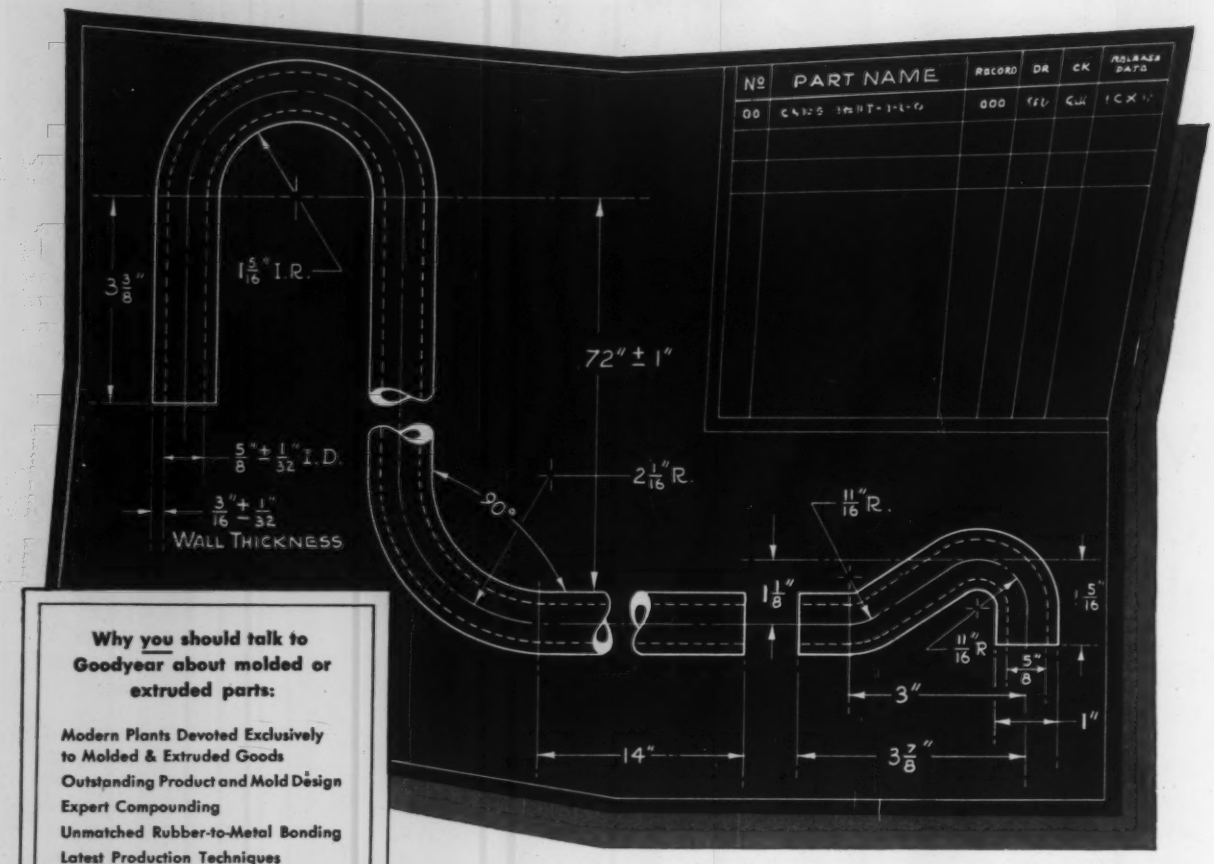
Blueprint for "cost reduction #EM-581"



Why you should talk to Goodyear about molded or extruded parts:

- Modern Plants Devoted Exclusively to Molded & Extruded Goods
- Outstanding Product and Mold Design
- Expert Compounding
- Unmatched Rubber-to-Metal Bonding
- Latest Production Techniques and Equipment
- Skilled Production Personnel
- Audited Quality Control

On drain hose—costs cut up to 40%

Detailed above is one of the many types of washing machine drain hose made by Goodyear for leading appliance manufacturers. Behind this part lies a story of savings which is typical of much of the molded and extruded rubber and plastics goods that flow from the modern Goodyear plants at St. Marys, Ohio, and Los Angeles, California.

It used to be that drain hose was a relatively expensive accessory to purchase. But today, through custom compounding and suggested changes in the design of the product, Goodyear has dropped the price as much as 25% to 40%.

What's more, the need for resistance to heat, water, detergents, flexing and age has been fully met, the quality of product actually improved.

The reasons why Goodyear can and does effect cost reductions on many types of molded and extruded rubber goods are listed in the panel above. If you would like more information or an invitation to visit one of the plants, just contact your local G.T.M.—Goodyear Technical Man. Or write direct to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED AND EXTRUDED GOODS BY

GOODYEAR

60th

THE GREATEST NAME IN RUBBER

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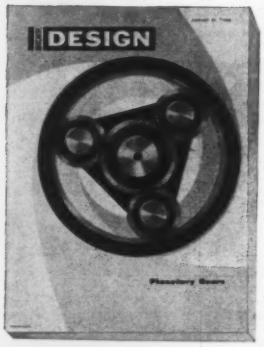

Front Cover: A whirling, planetary gear set is the central focus of George Farnsworth's front-cover design, highlighting Robert L. Benford's article on Page 129.

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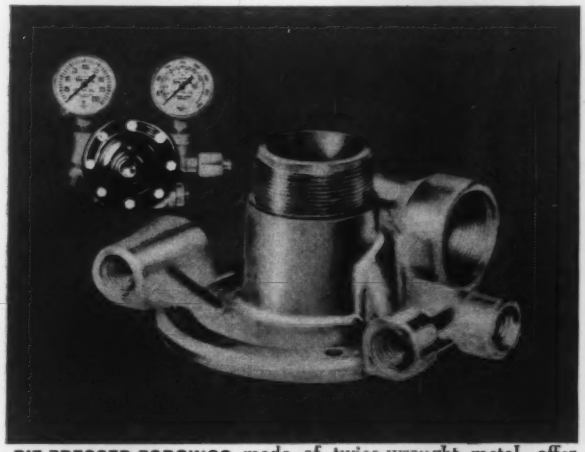
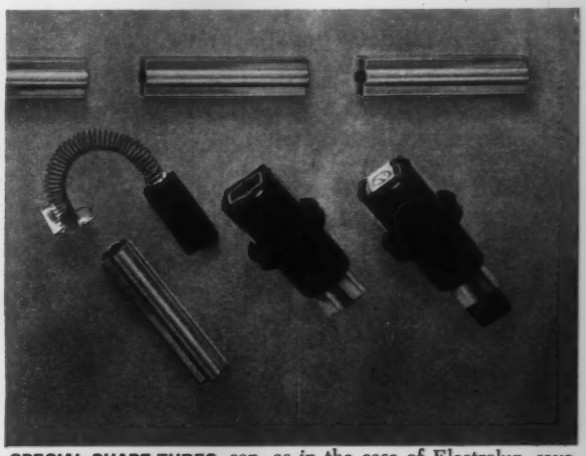
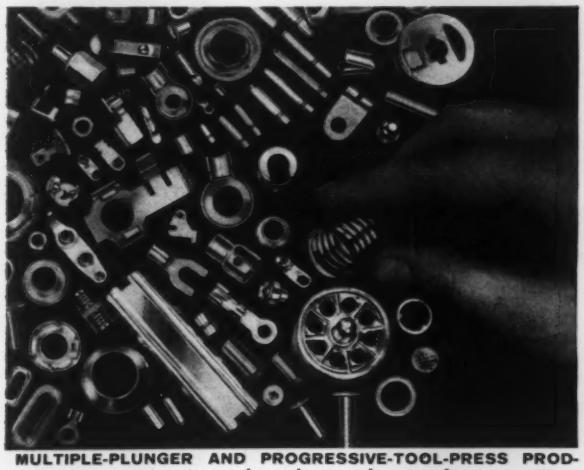
TAKE A FRESH LOOK at the way you are fabricating metal parts. Cost-cutting possibilities are almost unlimited with these Anaconda pre-formed mill products and press products.



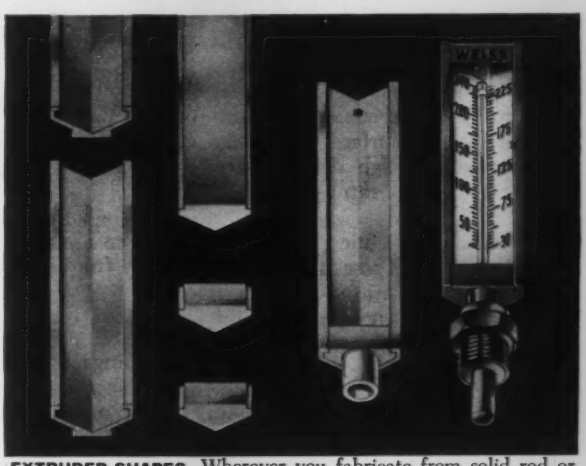
DIE-PRESSED FORGINGS, made of twice-wrought metal, offer superior uniformity, denseness, accuracy. *Savings*: replace more costly built-up assemblies—often are less in first cost than sand castings—require minimum surface machining to size—simplify secondary operations—lower tool cost—lower finishing cost.



SPECIAL-SHAPE TUBES can, as in the case of Electrolux, save several steps in arriving at a finished part. Brass electric-motor brush holder (above) is cut economically from long lengths of tube pre-shaped to accommodate both brush and spring. Uniform accuracy of all dimensions helps provide good brush stability.



MULTIPLE-PLUNGER AND PROGRESSIVE-TOOL-PRESS PRODUCTS are cutting costs throughout industry—often over 50%. Main reasons: The American Brass Company's complete design engineering service, long experience, specialized production equipment, a big selection of stock tools. Metals: copper, copper alloys, nickel, iron, steel, stainless steel, or aluminum.



EXTRUDED SHAPES. Wherever you fabricate from solid rod or bar—or castings—consider savings in machining, tooling and scrap by use of extruded shapes. Albert A. Weiss & Sons substituted two extruded shapes, above, for a sand casting—cut cost of thermometer case 41%, got an additional 30% saving in assembly because of consistently uniform dimensions.

HERE are four immediate approaches to cutting costs. Re-evaluate your designs and fabrication methods with these short cuts to finished products in mind. Wherever you spot a possible saving, send a sample, drawing, or description—with the quantity you need, the metal or properties you require—and ask for a quotation. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ontario. 5853

DIE-PRESSED FORGINGS • SPECIAL-SHAPED TUBES
EXTRUSIONS • FABRICATED METAL GOODS

products of

ANACONDA®

Made by The American Brass Company

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Plasma Jet Sprays Tungsten onto Steel

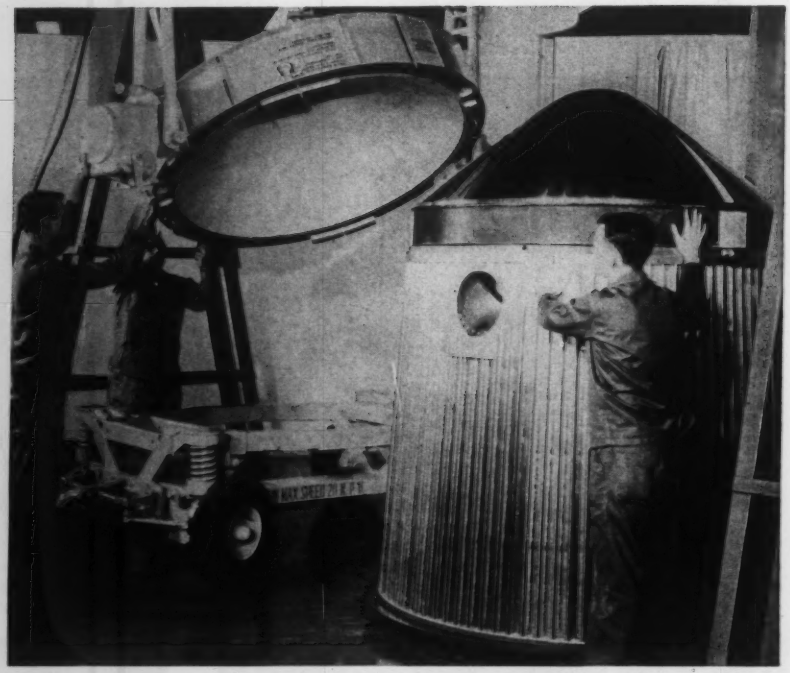
High Temperature, Velocity Give Strong Surface Bond

SANTA ANA, CALIF.—A new coating technique has been used to spray vaporized tungsten onto cold steel. Tungsten was used for demonstration because its boiling point at 10,600 F is higher than that of any other element in the periodic table. The technique can, reportedly, vaporize and spray any known element, or combination of elements, onto a support material.

Developed by the Giannini Plasmadyne Corp., the new process is the result of a recent development by which energy from an electric arc is transferred to an ionized gas medium, creating temperatures up to 25,000 F (MACHINE DESIGN, Feb. 6, 1958). Although the jet reaches velocities of 13,000 fps, it is easily handled and continuously monitored by control instruments.

A strong surface bond, high packing density, and surface smoothness are achieved through the combination of high temperature and velocity.

Immediate application is foreseen in protecting exposed structural metals, high-temperature pump and bearing surfaces, combustion-chamber valves and liners, and high-speed grinding and cutting surfaces.



THOR-ATLAS NOSE CONE, unveiled recently by General Electric, is shown being lowered onto a simulated Thor missile. The blunt, heat-sink cone is the result of one of the most expensive and concentrated research programs ever carried out in the U. S. It provides two ICBM's with the capability of massive retaliation, but it will probably prove significant only as a first step in the development of high-temperature materials. GE, who developed the critical component, also helps the Air Force to train personnel to attach the cone to the missile. Tests of the nose cone involve separation from a test missile and re-entry on a ballistic flight path.

Company Image Affects Engineer's Job Choice

Pilot Study Shows Unconscious Preselection

NEW YORK—Company image plays a key role in attracting technical men to an organization. Long before they actually enter the job market, engineers unconsciously choose certain organizations as potential employers and eliminate others from consideration. These findings by Deutsch and Shea Inc. of New York, resulted from a recent pilot motivational research study on company image and its role in technical recruitment.

Actual contact with a company is not necessary for the development of a strong image, the study indicates. Rather, technical men build their image on information gained through contacts with other engineers, on use of company products, on articles and advertising in newspapers and magazines. Company size apparently does not play a major role in company image. Engineers feel some concern that employment in a large organization will tend to stifle individual achievement and creativity. On the other hand, they have considerable, if reluctant, respect for the stability, prestige, and competence of large organizations.

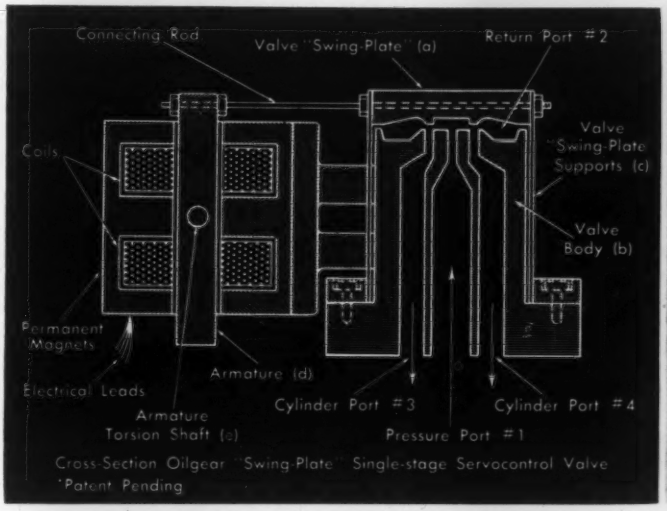
Engineer attitudes toward each other also emerged from this initial study. There is evidently a strong professional loyalty among engineers which transcends company boundaries. While they might be highly critical of a company's management, products, and personnel practices, engineers will not, as a rule, extend such criticism to the engineers employed by the company in question.

. . . Fluid Power news

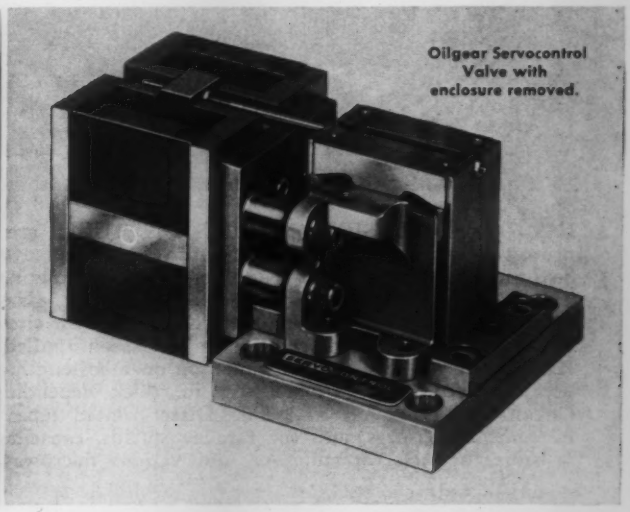
NEW INDUSTRIAL SERVO-CONTROL VALVES

New Oilgear Electrohydraulic Servocontrol Valves*

SERVO VALVE DESIGN OBJECTIVES: 1: Greater control accuracy and resolution for rotation and straight-line drives. 2. For industrial applications, must be capable of controlling wide pressure and volume range with single-stage, fast response to a low input signal. 3. Eliminate conventional valve frictional problems between spools and cylinders. 4. Eliminate two-stage linkage and stability problems. 5. Eliminate first-stage pilot systems — supply pressure, centering devices, filters, and orifices required for pilot systems. 6. Provide a flow rate substantially linear to valve displacement, with stability in null position. 7. Eliminate or substantially reduce valve "dead-band," sticking, jamming, scoring. 8. Be "fail-safe." 9. Operate safely in hazardous locations.



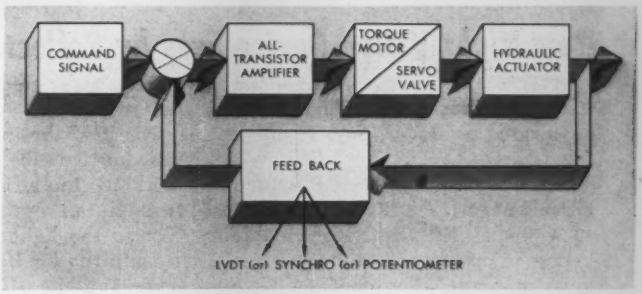
Cross-Section Oilgear "Swing-Plate" Single-stage Servocontrol Valve
*Patent Pending


Oilgear Servocontrol Valve with enclosure removed.

SOLUTION: 1. A new concept of three and four-way single-stage electrohydraulic servo valve construction . . . only two moving parts in Oilgear's new "Swing-Plate" design. 2. No metal-to-metal contact between "Swing-Plate" (a) and valve body (b) . . . frictionless for high sensitivity, fast response to minute signals — virtually eliminates sticking, scoring, jamming. 3. Clearances and port seal sizes can be varied to suit application and fluid handled. 4. Sharp, long rectangular chambers and lands linearize valve characteristics — flow rate essentially a linear function of valve displacement . . . supply high fluid power gain with minute "Swing-Plate" movement. 5. Hardened stainless steel construction assures reliable operation well in excess of a hundred million cycles, even with non-lubricating fluids. 6. No pilot system pressure, centering devices, orifices, or internal filters required. 7. Spring-steel supports (c) respond instantly to low torque motor forces. 8. As torque motor armature (d) pivots on torsion shaft (e), valve automatically centers in event of power failure for "fail-safe" operation. 9. For operation above 500 psi, a compensating cap equalizes hydraulic forces to maintain selected clearances. 10. No special modification required for use in hazardous locations. 11. Valves — open or enclosed — can be gasket-mounted. Pipe tap subplates are available.

PERFORMANCE DATA: Flow Rate — 4 gpm at 250 psi; 8 gpm at 1000 psi pressure drop across valve. Supply Pressures — to 3000 psi. Torque Motor; Mid Position Force — 11 lb min.; 5 watts max. power demand; Stroke — 0.015 inches; Hysteresis — less than 3%; Differential Current — 150 ma; Resistance per Coil — 80 ohms. Other coil current and resistance values available. Net Weight — 4¼ lb. Width: 4¾"; Height: 2¾"; Depth: 3".

Oilgear can supply all components for Fluid Power Servocontrol systems . . . all-transistor amplifiers, manual controls, preset controls, two-stage servo valves, variable displacement pumps, variable speed drives, motors and cylinders.



New Oilgear Servocontrol components applied to controls on Oilgear pumps and transmissions provide greater system accuracy and resolution. Functions easily attained with new Oilgear Servocontrol open and closed-loop systems are: 1. Precision, high-response speed control from zero to maximum rpm in either direction through remote control stations or switches. 2. Positive, high response, follow-up position control through remote command units. 3. Output motions or speeds with closed-loop systems will remain near constant with accuracies from 0.1% to 1.5%, and with resolution down to 0.05%.

For further information on these new valves and systems, call your Oilgear Application-Engineer. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

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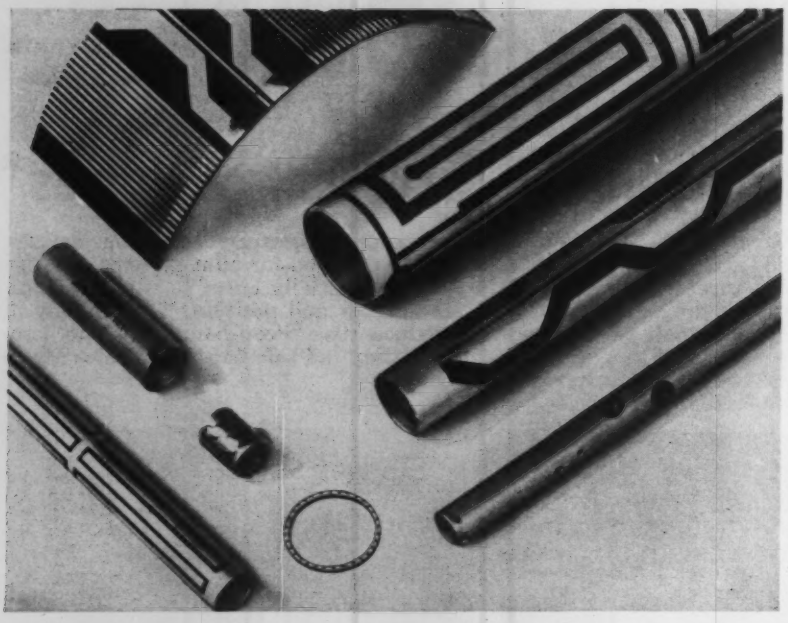
Please direct inquiries to advertiser, mentioning MACHINE DESIGN



INSIDE OR OUTSIDE CIRCUITS ON TUBES are printed by a new process developed at J. Frank Motson Co., Flourtown, Pa. Circuits can be applied to almost any type of nonconducting tubular material including Teflon, Kel-F, epoxy, phenolic, polyester, silicone, glass, ceramic, and thermoplastics. An ID of at least $\frac{1}{2}$ in. is desirable for circuitry, but continuous coatings for shielding or conduction have been applied to tubes having an ID of 0.020 in. There is no limitation on tube length. Conductive inks are deposited from 0.0004 to 0.0015 in. thick depending on requirements. Circuits are stable up to 500 F. Direct-printed tubes have been used as instrument housings, and for faraday shields, capacitance-type fuel gages, resistors, heaters, commutators, and various microwave parts.

New Night Vision Device Sees by Reflected Starlight

Has Greater Range Than Infrared or Radar, Says Army

WASHINGTON — Cascaded Photosensitive Image Intensifier is the name of a powerful device which enables Army troops to see military objectives at night. Developed by U. S. Army Engineer R&D Laboratories, Ft. Belvoir, and RCA, Harrison, N. J., the new weapon has a much greater range than its counterparts presently in use.

Entirely different from infrared, radar, and other mediums, the new device gathers reflected starlight or diffused light from skyglow falling upon the objective. It then intensifies, or amplifies, the diffused light sufficiently to present a clearly-defined image. The device is free from the complexities associated with low-level light intensifier television systems and requires no source of artificial light or radiation.

Heart of the instrument is a cascaded image tube, actually two tubes working in series and operating through an optical system, which focuses the light reflected from objects in the field. The first tube acts as preamplifier for the second which in turn further amplifies or intensifies the light and presents the image on the viewing surface. The tube requires low current at approximately 25,000 volts, and is powered by a compact six-volt battery through a system of transformers and transistors.

Possible civilian uses for the tube includes installation on an astronomical telescope to extend its range and sensitivity; in the making of certain x-rays using a substantially reduced level of radiation, or viewing of minute flashes of light emitted by nuclear particles to aid in basic research.

Topics

A breath of quiet air may solve economically the twofold problem of noise control and ventilation in factories and offices. In a technique developed at Illinois Institute of Technology, air is forced through the holes in an acoustical ceiling. Entering a room by this means, fresh air creates a resistance to noise, absorbs it, and is then available to perform the task of ventilation.

• • •

No knots in new nets make for more efficient fishing, thanks to synthetic fibers which can be fashioned into nets without need for tying. Some advantages of the knotless synthetic nets are they do not damage fish; they are strong, lightweight and not bulky; they offer less resistance to water currents, and they are less likely to collect dirt and microbes than conventional nets.

• • •

More engineering students were enrolled in September, 1957 than ever before, according to a recent report issued by the Department of Health, Education and Welfare. Data on institutions that confer engineering degrees (and not including other colleges where students are preparing for engineering) show a total enrollment of 297,077 for 1957, which was 7.2 per cent greater than 1956.

• • •

Discriminating radar speed checker— the first to be designed and manufactured in Great Britain—provides separate readings on vehicles which are only 8 ft apart. Compact equipment, consisting of a transmitter-receiver unit with aerial and a meter unit, weighs only 21 lb. It is made by Marconi's Wireless Telegraph Co. Ltd. and named PETA (for portable electronic traffic analyzer).

• • •

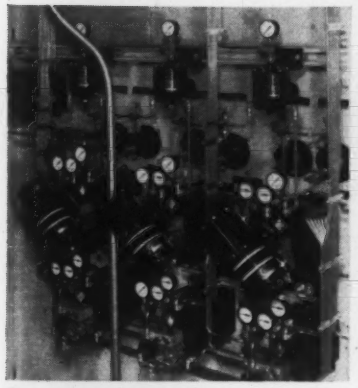
Landings without a pilot at the controls have been accomplished with a big Boeing 707 jet transport. Equipment used was Bell Aircraft all-weather landing system, which was developed for the Navy and Air Force. The Boeing jet transports will go into commercial service this fall.

• • •

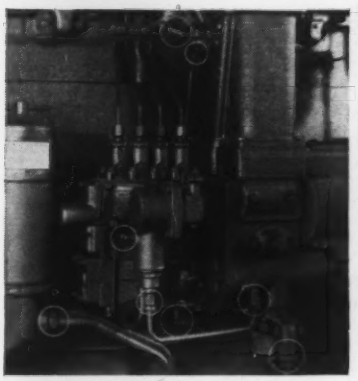
Needle-threader for show, not for sew, is one which employs Lear Electrolinks to accomplish this ticklish operation automatically, thereby demonstrating the accuracy of these electronic devices. Three of the closed-loop servomechanisms move the thread right and left, up and down, and forward and backward. Control dials can be preset so that when the Electrolinks are energized, the thread is placed through the eye of the needle.

Cut installation time 36 to 77%

with IMPERIAL Hi-Duty® tube fittings

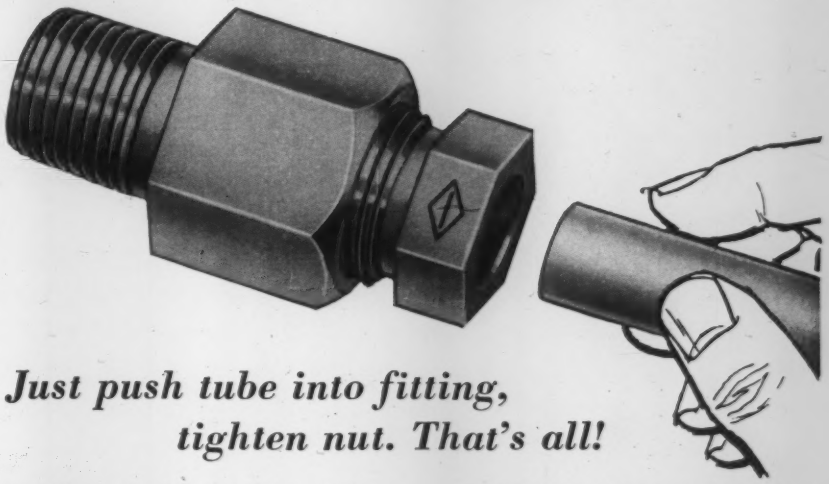


Rear view of a graphic panel used to control a Platform® Unit, built by Panel-lit Inc., Skokie, Ill.



Millions of Hi-Duty fittings in use on O.E.M., instrumentation and replacement jobs. Hi-Duty fittings can be disconnected and reconnected repeatedly without danger of leakage. Extra-strong forged bodies on elbows and tees, long Dryseal pipe threads and generous hexes. Available in brass and aluminum. For use with copper, brass, aluminum, Bundyweld, GM, block tin, Monel and other metal tubing — ⅛ to 1" O.D.

For complete data, ask for Bulletin No. 3002.



Just push tube into fitting, tighten nut. That's all!

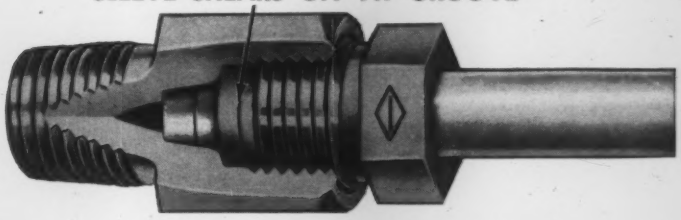
Whether you use 10 Hi-Duty fittings or 500 per installation, seconds saved per fitting will quickly add up to man-hour profits!

Four-to-one edge over flared fittings — A man can easily assemble up to four Hi-Duty fittings in the time it takes to assemble *one* flare fitting. Spot tests show only 11.7 seconds on the average are required to install Hi-Duty as compared with 48.2 seconds for an ordinary flare fitting. A minimum 77% boost in efficiency for you.

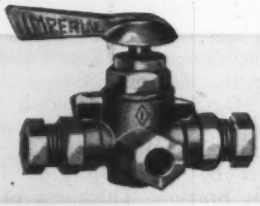
One-third faster than compression fittings — Same tests showed Hi-Duty installation required only 11.7 seconds compared with an average of 18.5 for compression fittings. A boost of 36% in efficiency!

Hi-Duty joints absorb 5 times as much vibration as compression or flare fittings — Sleeve on Hi-Duty fittings shears off during assembly and becomes permanently attached to tube. Always remains in perfect alignment. Joints stay liquid-and-gas tight.

SLEEVE SHEARS OFF AT GROOVE



Furnished in Brass and Aluminum



Hi-Duty® SHUT-OFF VALVES — First choice for perfect fluid control! Positive shut-off. Solid bottom — no chance for leakage. Spring-loaded stem with "O" ring seal maintains proper tension on nickel-silver plug at all times. 2, 3 and 4-way types for low and medium pressures.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
Dept. MD-88, 6300 W. Howard St., Chicago 48, Ill.
In Canada: 18 Hook Avenue, Toronto, Ontario

Emblem of Quality

SEE YOUR IMPERIAL DISTRIBUTOR — he carries the industry's most complete line of tube fittings and tubing tools.

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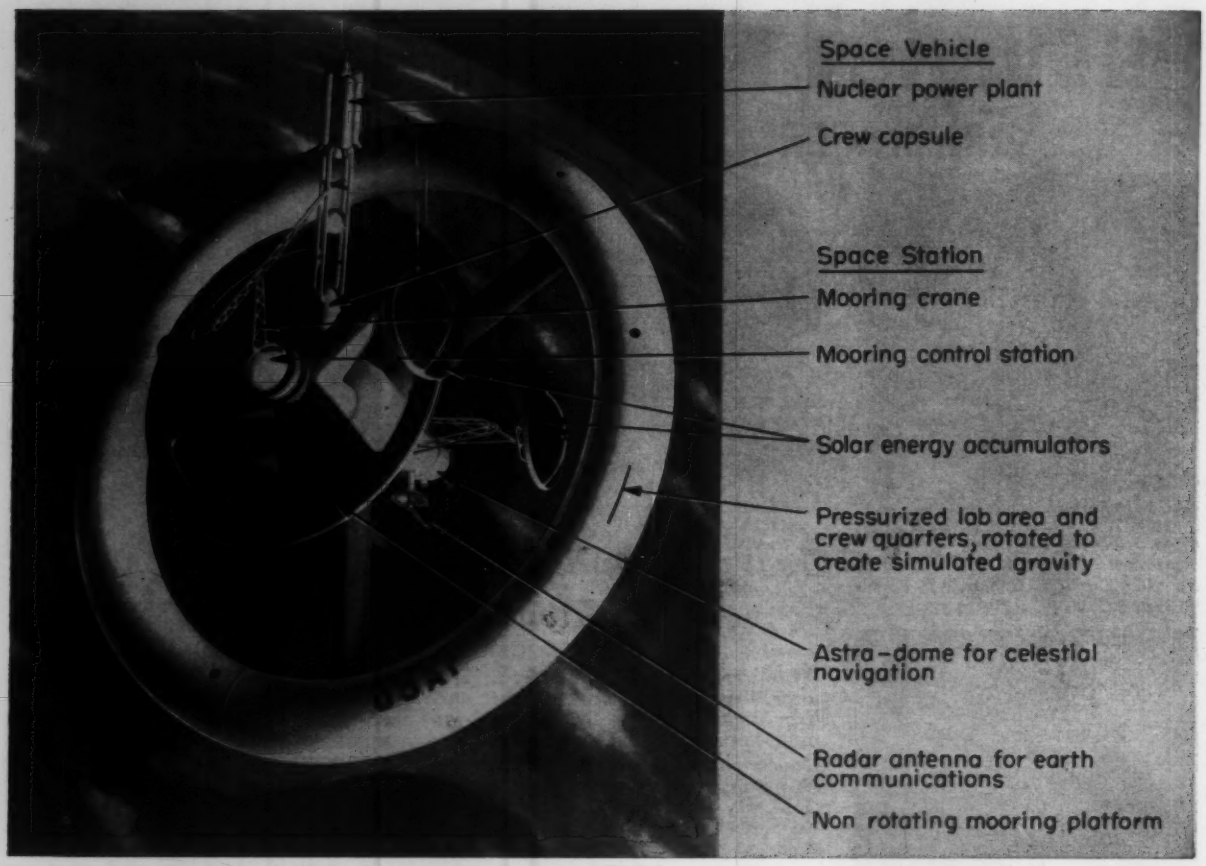
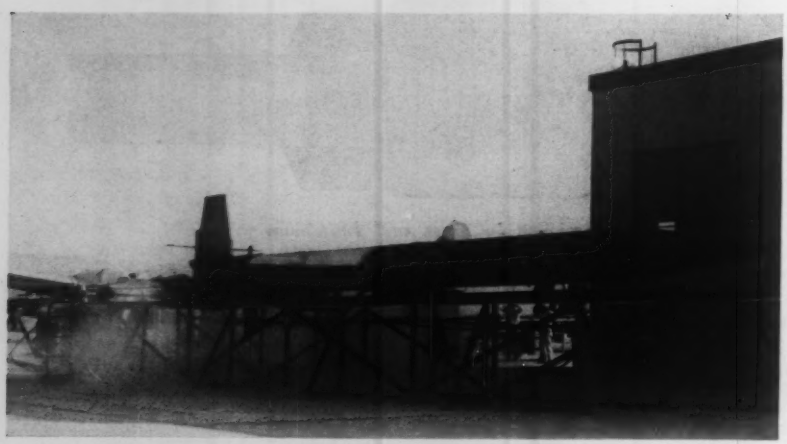
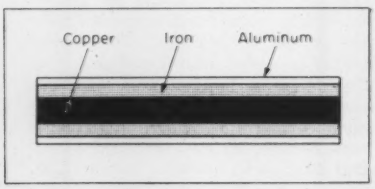


OUTPOST IN SPACE with mooring nests for three interplanetary vehicles is a conception of Lear Inc. The company will design and build a space-ship crew capsule for the Air Force, and preliminary studies of mission and capabilities of the ship include a design knowledge of the space station. This wheel-shaped model, a city block in diameter, would orbit 22,000 mi above the earth's equator. Its function would be equivalent to that of an aircraft carrier—to serve as a base of operations for defense or reconnaissance vehicles.

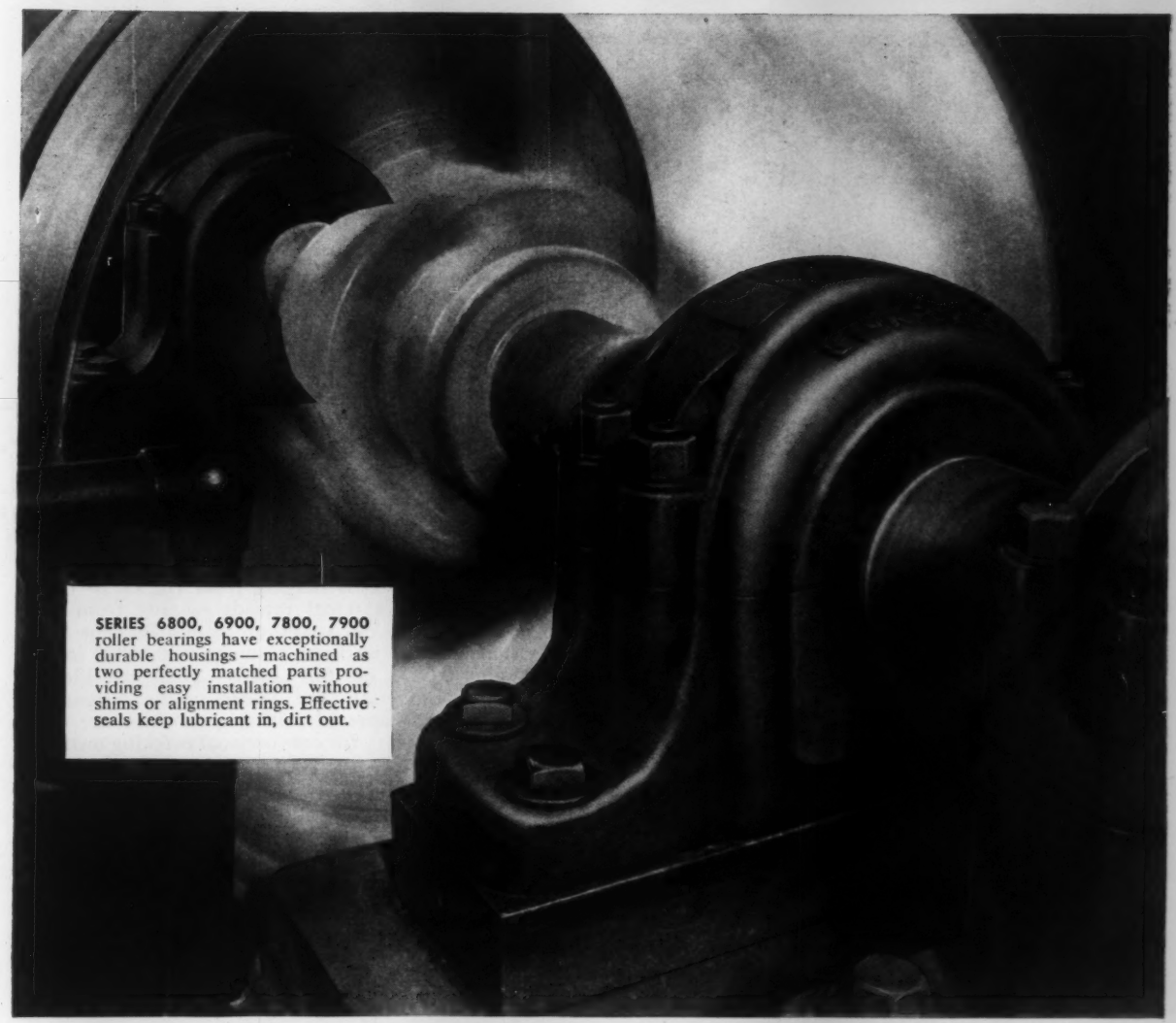


G-SHOOTER is what Lockheed Aircraft Corp. calls this missile-on-rails test facility. It provides a quick means of confirming workability of the missile's electronic components at 18-g acceleration, prior to launching. The missile travels a scant 2 ft in 0.04 sec and slams to a stop. Eight bands of nylon webbing strung under the rails act as brakes. Four of the webs stretch and snap to prevent rebound, the remaining four are a safety factor. A piston acting under 2100 psi furnishes propelling force.



FIVE-LAYER ANODE PLATES for vacuum tubes permit higher operating temperatures because of better heat dissipation. Developed by Metals and Controls Corp., Attleboro, Mass., in co-operation with General Electric Co., the new aluminum-iron-copper strip is clad together by a metallurgical bond without brazing. Thickness of the individual layers is closely controlled to assure over-all physical and operational uniformity. The new material is produced in continuous strip of nominal widths in thicknesses down to 0.007 in. On heating, a high-emissivity aluminum-iron compound forms on the surface.

NO PINCH, NO BIND-- ALWAYS-ALIGNED

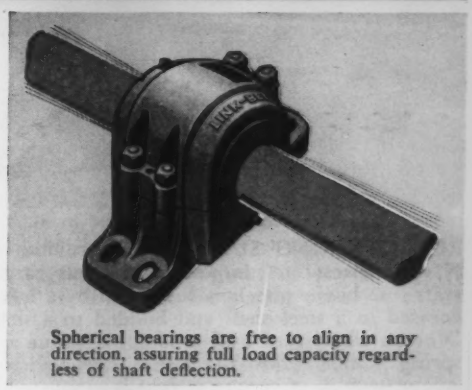


SERIES 6800, 6900, 7800, 7900 roller bearings have exceptionally durable housings — machined as two perfectly matched parts providing easy installation without shims or alignment rings. Effective seals keep lubricant in, dirt out.

These husky bearings in husky housings adjust *instantly* to shaft misalignment

Shaft deflection often means quick failure for ordinary bearings . . . but not for these rugged Link-Belt *self-aligning* bearings. Adjusting immediately in any direction, they easily compensate for misalignment . . . avoid damaging "pinch" and bind.

You can get full information on Link-Belt's complete bearing line from any one of 40 Link-Belt offices.



Spherical bearings are free to align in any direction, assuring full load capacity regardless of shaft deflection.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,905-A

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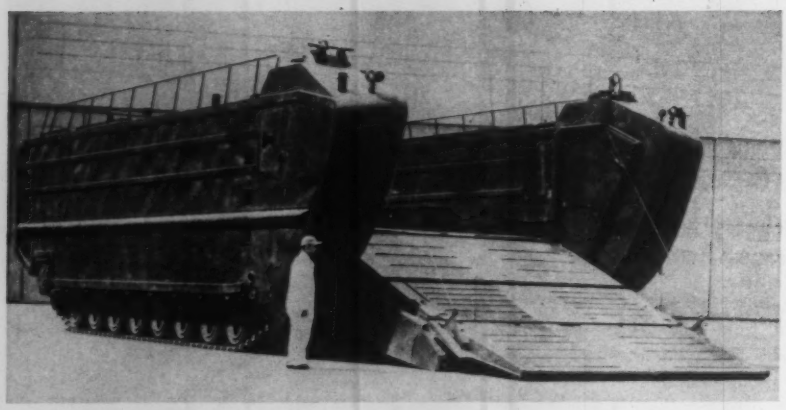
HONEYCOMB MACHINE forms and welds strong honeycomb core from foil-thin metal ribbon. Stock from 3/32 to 2 in. wide, and 0.001 to 0.006 in. thick is fed into the machine from spools where it is roll-formed into a corrugated pattern. Corrugated strips are then pressed against adjacent strips, forming strings of square or wave cells. Needle-like welding heads, which move up and down the corrugated strips where the convolutions make contact, perform up to 240 resistance welds per second. Layer upon layer of cells is thus added until core has reached the desired width. Solar Aircraft Co. developed the machine.

THREAD LEAD-AND-TAPER CHECKER developed by Pratt & Whitney Co. combines ability to check the lead of straight or taper threads, internal or external threads, and taper of threads or cylinders. It will handle internal threads ranging from 1¼ in. to 16 in. in diameter, and external threads ranging from 0 to 16 in. Workpiece can weigh up to 500 lb. The high-precision unit makes direct readings to 0.00002 in. for lead, and 0.0001 in. for taper. Called the Electro-Mechanical Universal Lead Tester, it was designed to check lead and taper of API gages, which are often too big or too heavy for conventional checking methods.

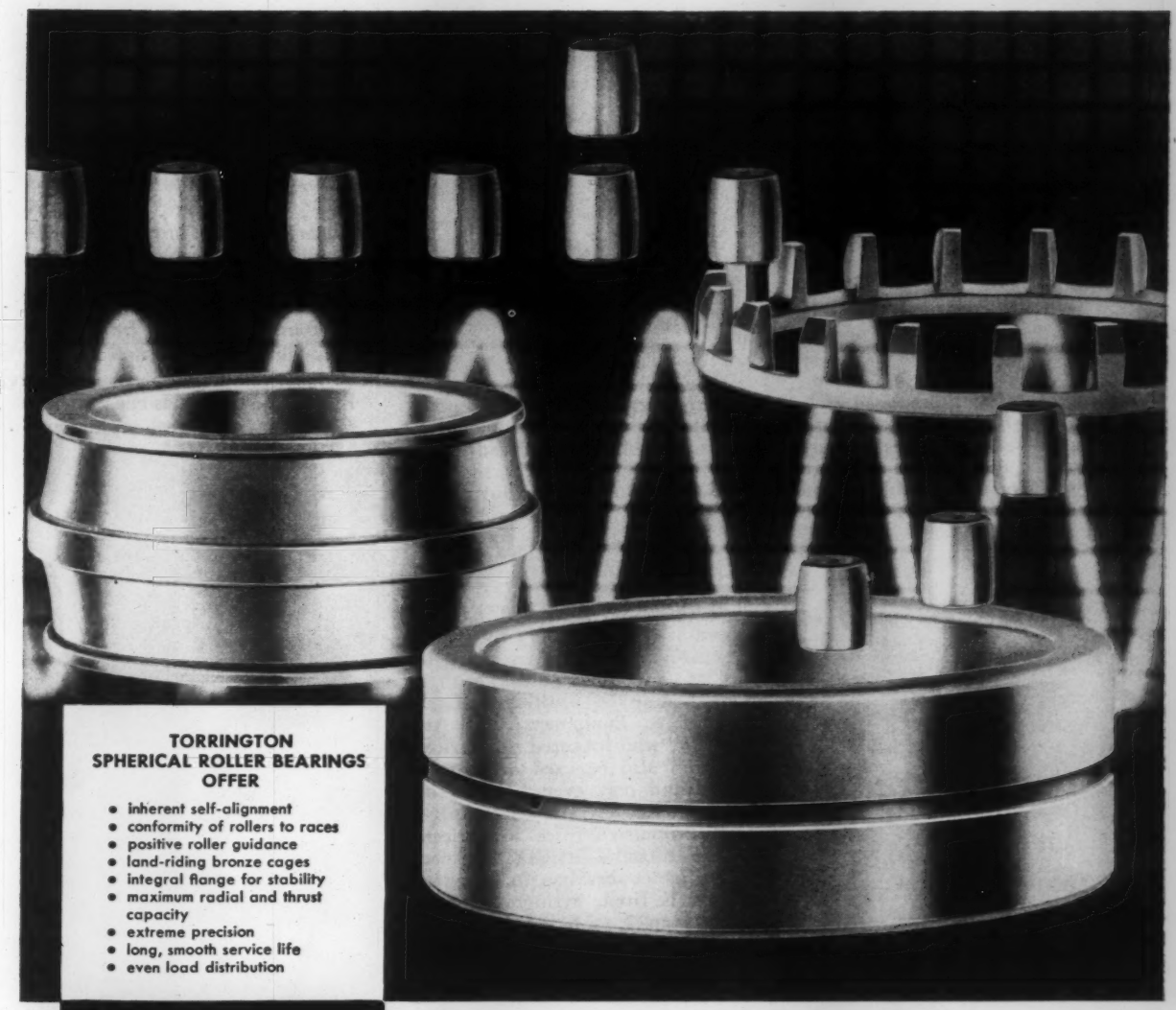


RUBBER-SPRING SUSPENSION provides smooth-going on land for the Navy's newest and largest amphibious cargo carrier. Each of the 60-ton craft's 32 bogie wheels is cushioned by a 3-ft long cylindrical rubber spring encased in a steel shell and bonded to a shaft locked to the vehicle's hull. When a wheel runs over a bump, a torque arm connecting each wheel to its spring pushes against the spring, causing it to twist and swallow the bump. About 9400 lb of sprung weight is supported by 36 lb of rubber used in each spring. B. F. Goodrich Industrial Products Co., Akron, Ohio, designed and manufactured the springs. The new cargo carrier, designed and built by Pacific Car and Foundry Co., Renton, Wash., travels 7 mph in water, 13 on land. Two steerable propellers retract into hull for land operation.

More Aluminum in Cars Forecast for '59

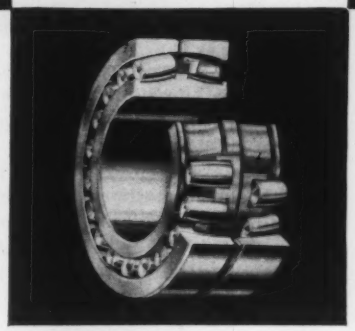
DETROIT — The average amount of aluminum used in the manufacture of 1959 cars will increase 14 per cent over 1958 models, according to Kaiser Aluminum & Chemical Sales Inc. Usage per car will be 57.1 pounds, compared to 50 pounds in 1958 and 46.3 pounds in 1957. More spectacular increases are predicted for the early 1960's when major components such as engine blocks, wheels, bumpers and radiators may be made of aluminum. Cast applications will then total about 72 lb of aluminum per average car, more than double the 1958 demand for aluminum castings.

Chrysler Corp. automobiles, as in 1958, will use the highest per car average with 73 lb, an increase of 6 per cent. The company's Imperial line again will lead all automobiles with an average 131.5 lb per car.



TORRINGTON SPHERICAL ROLLER BEARINGS OFFER

- inherent self-alignment
- conformity of rollers to races
- positive roller guidance
- land-riding bronze cages
- integral flange for stability
- maximum radial and thrust capacity
- extreme precision
- long, smooth service life
- even load distribution



Electronics Matches Rollers and Races for Extreme Accuracy

Torrington employs the latest electronic techniques to insure precise geometric relation between components of Torrington Spherical Roller Bearings.

Roller diameters of a given complement are matched within .0001" of each other. For ultra-precision bearings, tolerances are even closer. Inner and outer races are as rigorously classified. Components are selected for assembly to provide accurate diametrical clearance. The result is bearings of unparalleled accuracy for minimum wear and friction, smooth operation and long service life.

Torrington's care for these details of accuracy is matched only by our care in matching the *right* bearing to the *right* job. In this, you can rely on your Torrington representative and the facilities of Torrington's Engineering Department. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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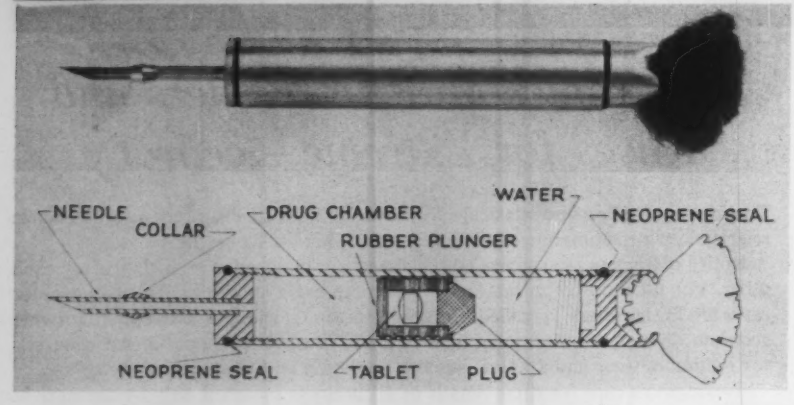
TOYOPET CROWN, described as Japan's prestige car, is another new entry in the booming U. S. foreign-car market. It will be available in a four-door, six-passenger sedan, and is powered by a four-cylinder, overhead-valve engine rated at 60 hp. Over-all length of the Crown is 14.5 ft, height is 5 ft —about the size of a Rambler American. Fuel consumption is said to be 33 mpg. Manufacturer is Toyoda Motor Co., Nagoya.

BIG-GAME TRANQUILIZER is injected at a safe distance by firing the entire syringe from a gun. It stuns the animal for 30 min with a harmless dose of nicotine. Palmer Chemical & Equipment Co., Atlanta, Ga., who invented the device, say it can also be used on rioting humans and may even be used in future wars to capture enemy prisoners. Propulsive force for injecting the nicotine is CO_2, formed when a tablet dissolves in water as the gun is fired. Syringes vary in length from 2 to 6 in. depending on animal size.



New standards and tolerances for commercial forgings are under preparation by a committee of engineering and production executives of Drop Forging Association member companies. The plan is to publish in complete form—for convenient use by designers, metallurgists and engineers—the latest technical information on modern forgings. According to the committee, "Forgings are now evaluated by the customer through well established quality control techniques, and standards must be designed to help the trained quality control people."

Tiny Medical Flash Camera Snaps Photos Inside Stomach

Permits Detailed Diagnosis In Black and White or Color

BOSTON—A miniature camera, less than ¾ in. long and 5/16 in. in diameter, permits internal surface areas of the stomach to be photographed for the first time while being viewed. It takes pictures comparable in quality to the best photographs taken under natural or artificial light conditions.

In use, the camera is encased in a 2 x ⅜-in. stainless-steel capsule and

attached to a gastroscope—a common medical instrument for viewing human interiors. Both units are swallowed by the patient.

A fixed-light assembly, located below the camera shutter, uses a special ¼-in. diameter, low-amp bulb with a shutter timing surge of 40 v. Camera and flash attachment are triggered via an 0.008-in. wire running through the gastroscope. When the bulb is triggered inside the stomach, its light value is equal to that of a normal flash bulb attached to a standard camera.

Film, with eight exposure areas, is wrapped around the drum-shaped camera which rotates inside the stationary capsule. A 45-deg mirror and shutter release are also encased within the rotating drum. The camera lens is located at an equal distance from all exposed areas of

the film, which makes pictures completely free from distortion. The 3/16-in. original negative can be enlarged 10 times without further distortion, and a viewer-size picture approximately 2 in. square can be projected through usual projection methods for detailed study.

Inventor of the unique internal gastro-camera is Norman R. Gosselin, medical research engineer for the Charles Brush Medical Center, Cambridge, Mass. Mr. Gosselin is a graduate of Boston University's College of Industrial Technology.

LONGER ARM FOR THE LAW is provided by new pocket-size, two-way radios being used by New York City police. Developed by RCA, the portable stations have a range of more than 2 mi. Receiver weighs 10 oz, is equipped with either a small lapel loudspeaker or an earpiece reproducer. The FM transmitter weighs 28 oz and uses a carbon-type microphone. Both units are fully transistorized. Power supply is a battery with 150-hr life.

Metal-ceramic combination that can withstand temperature of 5000 F is in development stage at Bettinger Corp., Waltham, Mass. Currently in production are metals coated with ceramics and bonded at 2600 F. These combinations will withstand much higher temperatures in actual use.

DRAFTING TRENDS

Sharp cloth intermediate prints can now be made with present diazo process equipment right in your own department by using Post's new 208TC (black) or 209TC (sepia) cloths.

New intermediate cloth for ammonia process diazo prints

One of the big stumbling blocks in more widespread use of intermediate papers and cloths has been the lack of a good, sharp, dense *black* for ammonia process equipment.

One year ago the big news was that Post laboratories licked the problem in intermediate *papers* with the introduction of an improved Vapo Black. Now there is further news . . . just recently Post introduced 208TC, a highly transparent intermediate *cloth* giving sharp, black images. A companion product, Post 209TC, gives the same advantages in sepia.

Using 208TC or 209TC Vapo Cloth, you can produce highest quality cloth intermediates in your own department with your present diazo process equipment. It is a convenient, low cost, single operation method requiring no negatives.

Tough intermediates save originals

The durable, premium quality white tracing cloth base stock holds up well even after prolonged filing. In accelerated aging tests, Post 208TC and 209TC prints were held at 100°C for 20 hours. At the end of that time there was *no* evidence of bleeding . . . while transparency loss was minor.

Interestingly enough, printing speed (making the intermediate) of both products is unusually high. Even more important, there is no sacrifice of image density to obtain this high speed. Prints are still strong, clean and dense. Similarly, print-back speed is fast with crisp prints the result every time.

Prints better than originals

In many instances, the "contrasty" emulsion makes it possible to increase the intensity of an original drawing and actually make the intermediate better than the original. But in any case, a print on 208TC or 209TC has the sharpness, contrast and density that are the marks of quality prints.

Of further importance to the draftsman is that the matte finish on these cloths has just the right tooth for both pencil and ink work. It makes drawing easier and speeds modifications.

For detailed information on 208TC and 209TC, see your local Post blueprinter or write to Frederick Post Company, 3652 N. Avondale Ave., Chicago 18, Ill.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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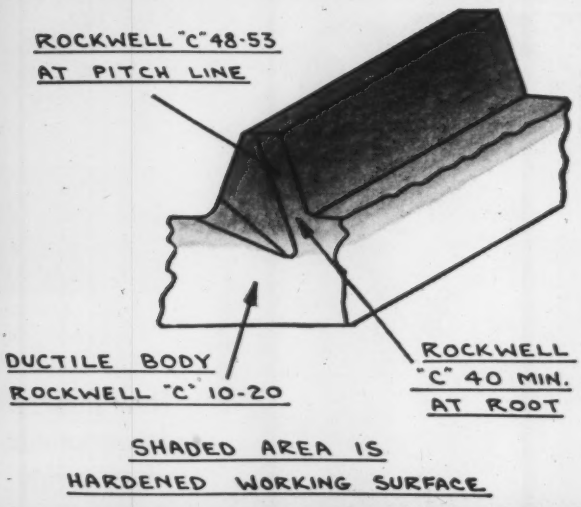
THIN! TOUGH! ...and "tender-hearted"



THE MANUFACTURE of flywheel ring gears poses special problems. Sectional thickness is usually less than three-quarters of an inch. To withstand the impact force of the starter pinion, the gear teeth must be hard. But the gear body itself should be unhardened so that it will conform tightly to the flywheel, and "give" under the stress that might snap a brittle gear.

Note how DOUBLE DIAMONDS are made to be thin, tough, "tender-hearted." The above photo of a gear twisted into a pretzel shape graphically demonstrates ductility. The sketch at right shows three important areas: the wide and deep hardness pattern, the generous area of transition, and the ductile body. These extremes are achieved in DOUBLE DIAMOND Flywheel Ring Gears by controlled selective heat treatment—all essential to flywheel ring gears that provide the best possible performance.

Our Engineering Department will be glad to make constructive suggestions on the design of flywheel ring gears, or on the many other types in which we specialize. Write, phone or wire—depending on the urgency of your need.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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MACHINE DESIGN

Reader Information Service

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
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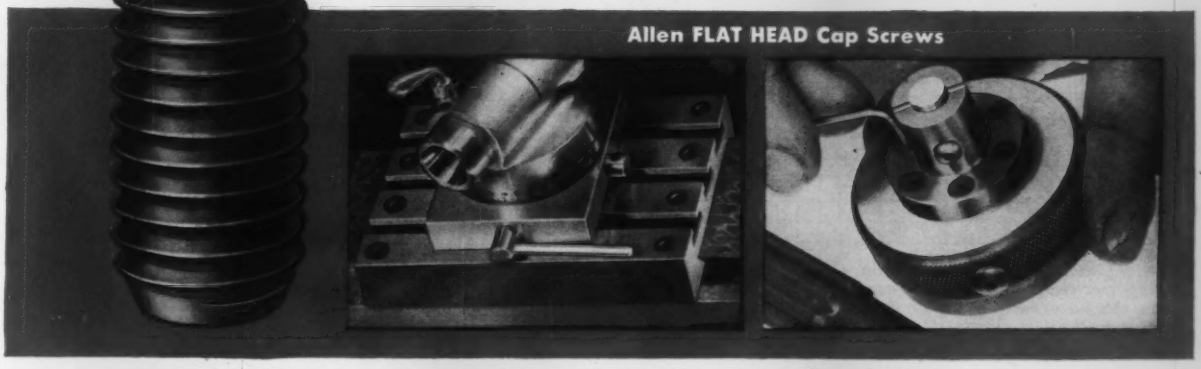
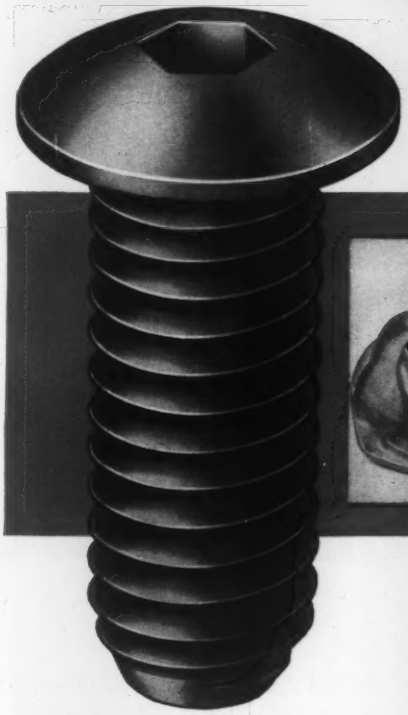
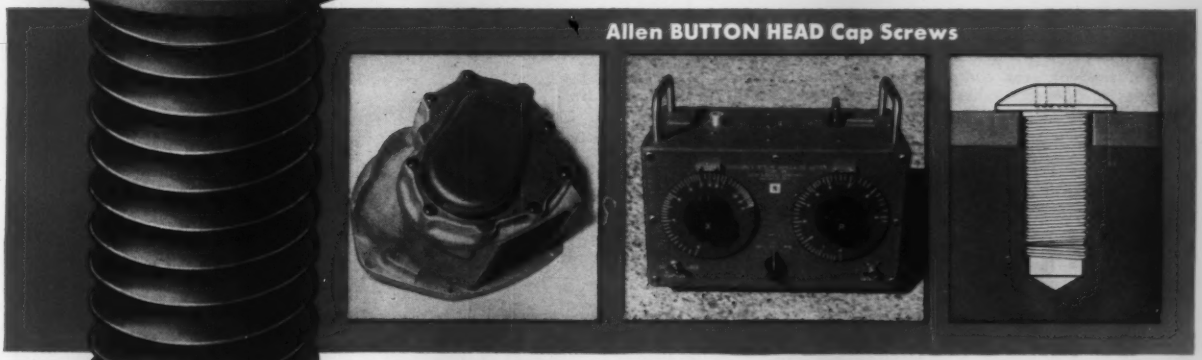
Reader's Service Dept.

Use genuine Allen tough-gripping fastening for your flush and streamlined surfaces



Allen Flat Head Cap Screws, in countersunk tapped holes, give you absolutely flush surfaces. Hex-socket wrenching entirely eliminates burred slots and protruding heads. Genuine Allen Flat Heads are "pressur-formd"—long fibers of the metal are preserved uncut throughout the whole length of the screw. Allen's exclusive Leader Point makes starting easier—prevents damage to lead thread. Class 3A fit; available in No. 4 through ¾" diameters. Write for FREE samples, dimensions, and full details.





Where you can't countersink—fastening thin metal parts like covers, access panels or guards, for example—Allen Button Head Cap Screws will give you the smooth, streamlined effect you want. Hex-socket wrenching assures a tighter hold—eliminates driver slips, raised metal slivers, and skids that can damage and mar parts and finish. "Pressur-formd," like the Flat Heads above, for far greater strength at vital points. Leader Point. Class 3A fit. No. 4 through ⅝" diameters. Write for FREE samples and full information.

The cost of Allen Hex-Socket Cap Screws is only a minor fraction of your assembly costs . . . be sure you're getting the timesaving, cost-saving advantages of *genuine* Allens.

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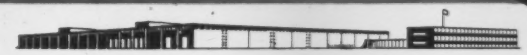
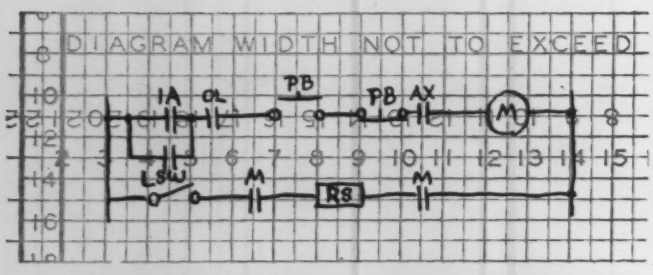
Ready in September . . . Allen's great new plant!

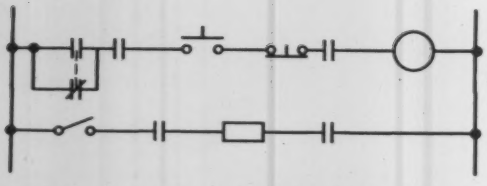


Circle 412 on Page 19

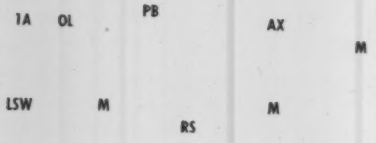
Electrical Diagrams by Photography



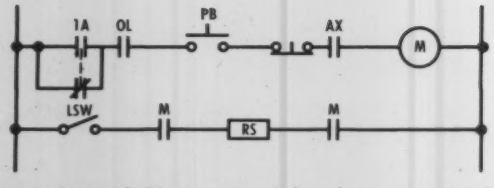
The engineer draws the circuit on a ¼-in. cross-section form, confining electrical symbols to separate ½-in. squares. Vertical circuit lines can be drawn on any of the ¼-in. lines. (Diagram, ½ scale.)



When the engineer completes a free-hand sketch of the circuit, the Fotosetter operator takes over. His version of the circuit looks like this when it emerges from the machine and is developed



Nomenclature and wire numbers are set in the same manner on a separate piece of film



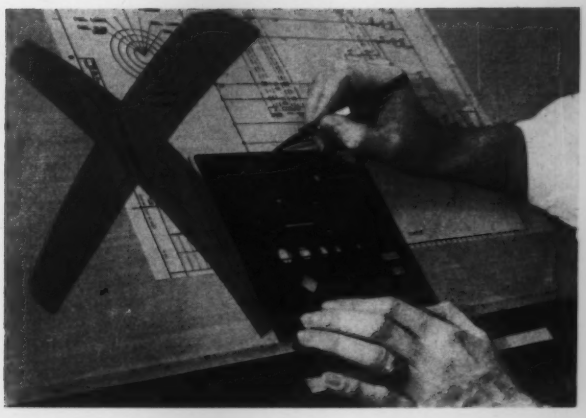
These two pieces of film are married and contact printed photographically to make the final diagram.

Fotosetter automatically reduces the lines, symbols, and spaces from ½ in. on the engineer's sketch, to ¼ in. on the final diagram. Completed diagrams are thus reduced to 8½ x 11 in. There is no stripping or patching, since the circuit is set on one piece of film.

Here's the first report ever published on a brand new method of turning out elementary diagrams of electrical circuits. It uses a time-proven machine to replace conventional drafting procedures . . .

Photo

SHARP, UNIFORM DIAGRAMS of electrical circuits are produced in a hurry by a new process developed at General Electric Co.'s Industry Control Dept., Roanoke, Va. No drafting is involved. The engineer makes a freehand sketch of an electrical circuit, passes it to the operator of a photo-composing machine, and the finished diagram emerges ready for photographic developing and duplication by any of the usual duplicating procedures. The result: Lines, symbols, and nomenclature are uniform, and the 8½ x 11 in.-



By PAUL E. DeLAWTER
Standards and Procedures Specialist
Industry Control Dept.
General Electric Co.
Roanoke, Va.

Composing Electrical Diagrams

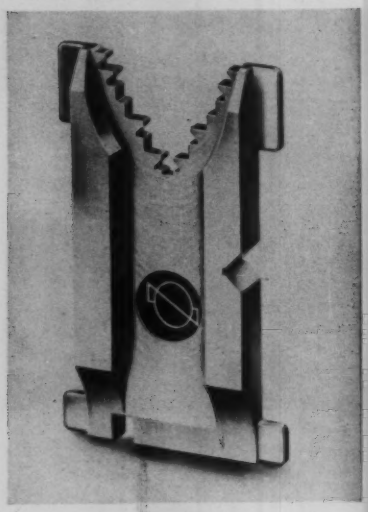
diagrams—one fourth the size of those normally used today—are easily read and are convenient for handling and filing. The entire procedure closely resembles the one used in composing this magazine.

Here's how the new process works:

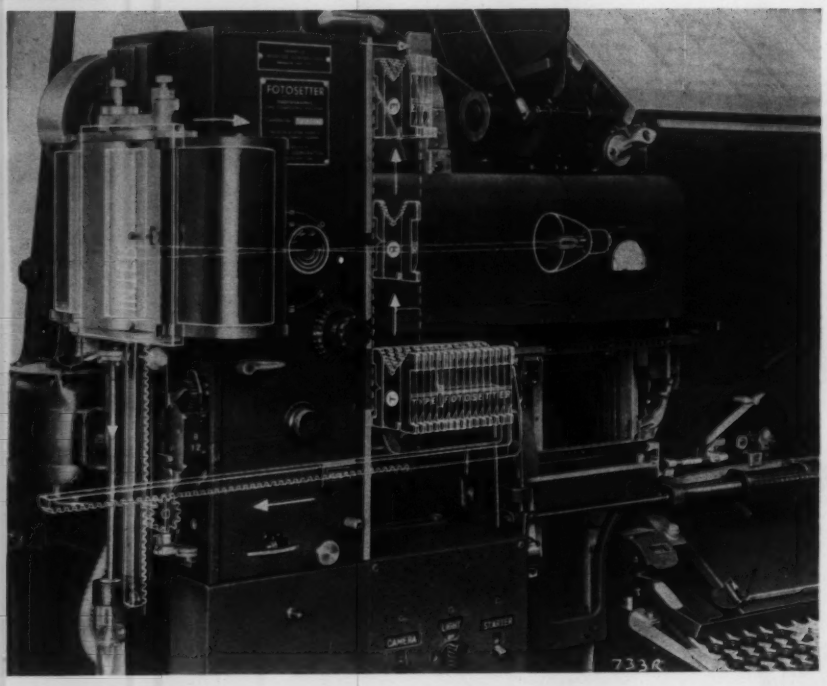
Diagrams are sketched on a form which is ruled especially for the job. Lines on the form are spaced ¼ in. apart, with each ½-in. line accented. Electrical symbols are drawn within the ½-in. squares formed by the accented lines. Horizontal circuit lines are drawn ½ in. apart; vertical circuits can be drawn on each ¼-in. line. Horizontal and vertical lines on the graph form are numbered so the operator of a Fotosetter Line Composing Machine can locate each symbol and supporting item that make up the electrical circuit. When the engineer thus completes his sketch, the pencil copy goes directly to the Fotosetter operator.

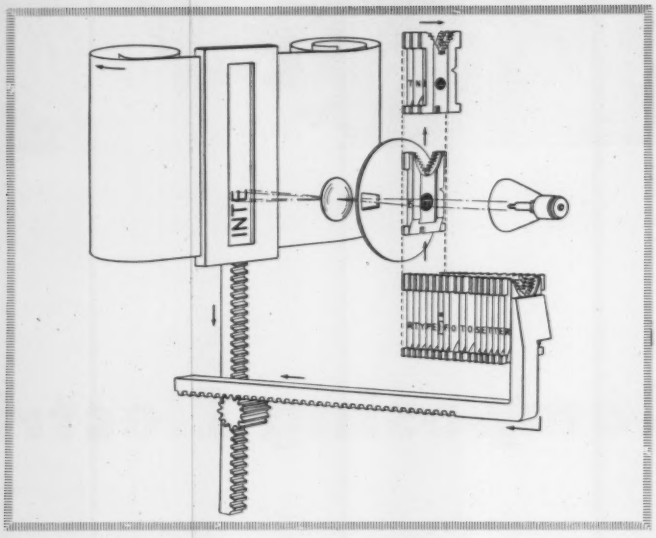
The keyboard-operated Fotosetter machine was developed about 10 years ago by Intertype Co., Brooklyn, N. Y. Since that time it has been used extensively in printing and type-composition plants. The machine incorporates a circulating matrix. Matrices, called Fotomats, are brass keys containing a film negative with the image of the electrical symbol and its connection points. Horizontal and vertical circuit lines are also on individual matrices.

The operator, referring to the engineer's free-hand sketch, sets each line of the electrical circuit by typing it out on the Fotosetter keyboard. As each horizontal and



Each Fotomat, or matrix, is a brass key containing an electrical symbol or any of the various other lines and type for drawing and lettering electrical circuits.





Fotomats feed through the camera portion of the machine and return to the magazine. Thickness of Fotomat determines spacing between letters. Type size, for lettering nomenclature, can be enlarged or reduced by changing camera lens. Equipped with an eight-lens turret, the Fotosetter camera can produce 11 different type sizes from two basic sizes of Fotomats.

vertical line is set, the symbols are exposed individually on a film positive. Symbols are automatically returned to their proper storage, and the film advances a prescribed distance to prepare for the next line. When the entire electrical circuit has been set, film is removed from the machine and developed in a dark room.

Nomenclature, wire identifications, and pertinent notes are set on a separate film positive in the same manner as the electrical circuit. A unique position indicator on the machine enables the operator to easily and accurately set these identifications so that they line up and overlay the electrical circuit.

Final diagram is made by combining the two positives. They are overlaid with a film containing the title blocks and are contact printed photographically to make the final tracing.

Corrections and engineering changes are quickly made. The portion in error is merely cut out of the diagram, using a special cutting device, and corrected information is set on the Fotosetter, then inserted and taped in the proper space.

According to Intertype Co., all of the equipment involved in the process—Fotosetter machine, correction and cutting equipment, and photographic equipment—is easily operated and requires no special experience or skills. Fotomats of all conventional electrical symbols are available.

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You rule out assembly slow-downs, assure consistent, quiet performance of your product, when you specify G.S. Hobbed Pinion Rods... available up to ⅜" diameter, up to 12 feet in length, in various shapes and materials. Why? Because G.S. specialized experience, specialized equipment, specialized techniques, *and rigidly controlled precision processes* mean unsurpassed quality in G.S. production runs of all forms of Small Gearing—Spurs, Spirals, Helicals, Bevels, Intervals, Worm Gearing as well as Pinion Rods.

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SEND FOR *G.S. technical data, free! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

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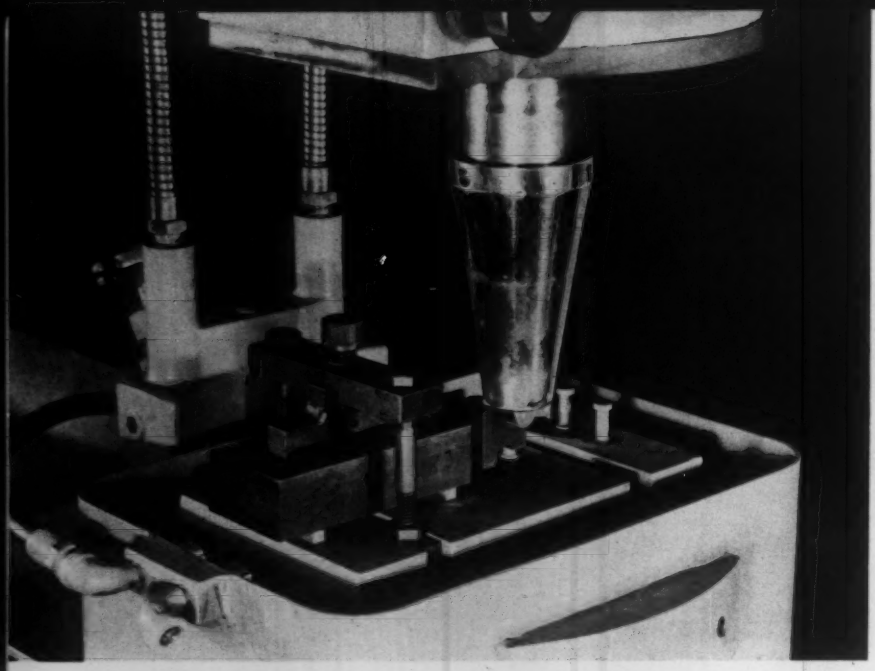


Right-angle grind
Ultrasonic tool path is at right angles to straight infeed of the tool. Sheffield Cavitron's conversion of a Gallmeyer-Livingston surface grinder uses ultrasonically energized tool shape for surface grinding a complex contour in a titanium carbide part.

Higher-than-sound frequencies are being exploited in new and ingenious designs for machine tools, home appliances, heat-transfer mechanisms . . .

Ultrasonics

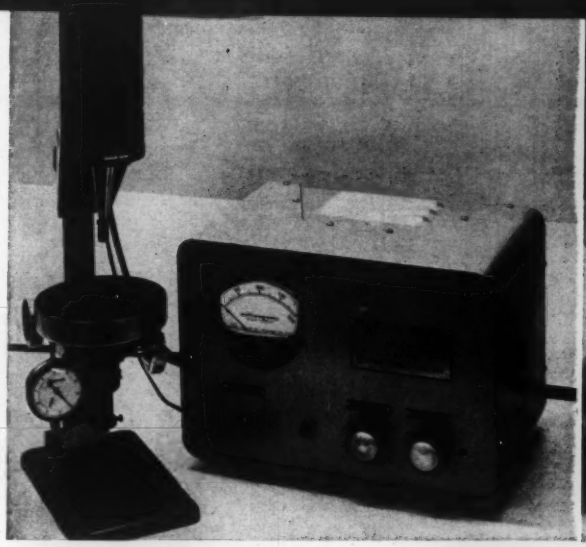
Ultrasonics today

For information and control	*For useful work*
nondestructive testing	cleaning
liquid-level sensors	drilling
delay lines	grinding
filters	soldering
viscosimeters	welding
flowmetering	heat-transfer improvement
remote control	plating
underwater signals	impregnation
	particle precipitation

ULTRASONICS, heralded around the world, does offer significant design possibilities. But some of its most serious proponents protest the "blue sky" acclaim it has received.

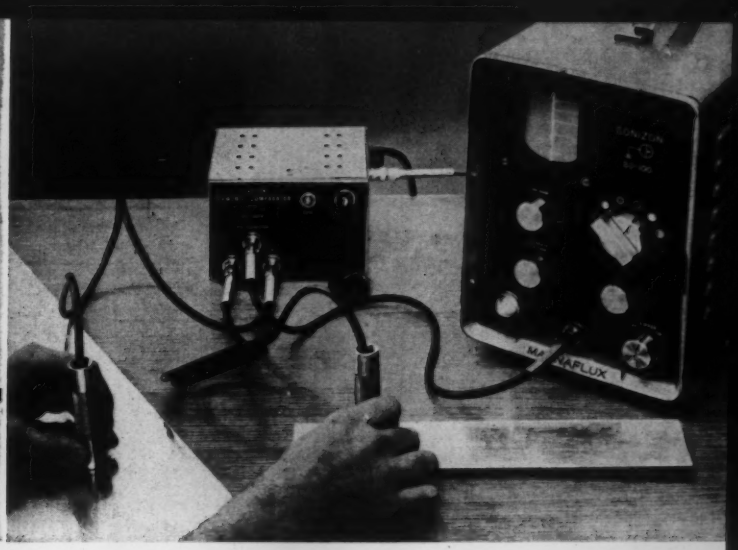
Explains Jack T. Welch, president of the Ultrasonic Manufacturers Association, "Too much is being said about miracles in the field instead of actual, solid accomplishments." He points to real opportunities: "Ultrasonics will enable engineers to use certain materials and shapes of materials for the first time because of its distinct advantages in the machining, inspection and cleaning of materials."

One project being carried forward today is the inducing of ultrasound into components of otherwise standard machine tool. Ultrasonics' "lubricating" qualities reduce running friction and make the tool freer machining or the workpiece easier cutting. Another project for cleaning glass will mean better surfaces that



Ultrasonic drill

Industrial ultrasonic drill made by Gulton of Metuchen, N. J., uses vertically oscillating tool to drive abrasive grains into the workpiece. Abrasive slurry flows between the tool and the workpiece.



Rapid thickness measurements

Thickness measurements are made by use of two ultrasonic probes. When the two patterns on the cathode ray tube coincide, thickness may be read from the marked block. The larger instrument may be used by itself to measure thickness, locate laminar-type defects or lack of bond between materials. (Magnaflux Corp. of Chicago.)

Aims at Maturity

can, for example, be coated like a mirror.

"New sizes of welding equipment are under development for spot and seam welding," says W. C. Potthoff of Aeroprojects Inc. in West Chester, Pa. "We are moving in two directions at once, developing larger equipment of interest to the aircraft industry and smaller equipment for the electronics industry, some of which is designed to weld junctions of wires only 1 to 2 mils in diameter. In addition, we are doing fundamental research in connection with the mechanism by which vibratory welds are produced. The results will have far reaching influence on the progress of this new, and already proven method."

Indicative of growing interest in ultrasonics is the First International Ultrasonic Exhibit and Conference, scheduled to be held in New York on Nov. 13-15. Sponsor of the show is *Ultrasonic News* of Mt. Vernon, N. Y.

An ultrasonic dishwasher intended for the home and a washing machine, farther off on the horizon, are being developed at Acoustica Associates Inc. of Mineola, N. Y. "But most items now in development are refinements of existing techniques," says its president, Robert L. Rod. "All of us are now trying to get more and more people in industry interested by refining the actual equipment we have, by reducing price, and improving quality." Cost of the home appliances, he contends, must be pared to figures that are really attractive pricewise.

Transducers

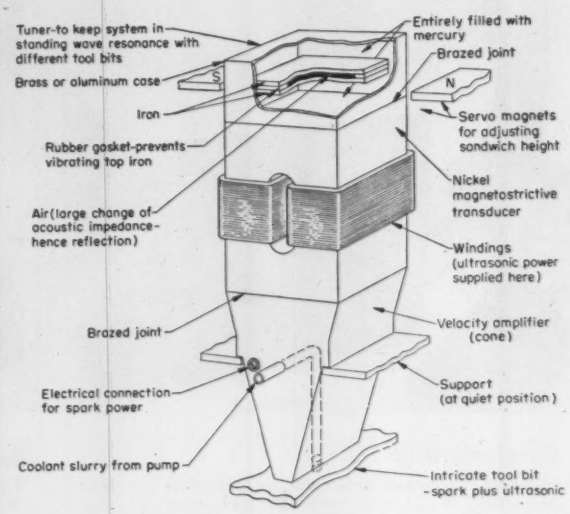
Heart of any ultrasonic equipment is its transducer system, which converts energy into ultrasound. In general, transducers are either magnetostrictive, piezoelectric, or fluid-dynamic devices. Principle of magnetostrictive transducers is that certain materials undergo appreciable physical changes under the influence of a magnetic field. Piezoelectric, or electrostrictive, materials change dimensionally under the influence of electric fields. Fluid-dynamic devices, on the other hand, periodically interrupt fluid flow to produce vibrations.

Among magnetostrictive materials are nickel, Alfer, Monel metal, Permalloy 40, cekos, and several other different ferrites.

Piezoelectric crystals can be either natural elements or man-made. Among them are Rochelle salts, quartz, barium titanate, ammonium dihydrogen phosphate, and lead titanate zirconate. Clevite Corp. of Cleveland recently developed a new piezoelectric material, expected to cause a boom in the production of stereophonic sound equipment. The new material responds either to lateral or hill-and-dale variations in

Ultrasonic welder

Welding equipment, made by Aeroprojects Inc., fabricates aircraft materials such as 2024-T3 Alclad aluminum.


Tuner-to keep system in standing wave resonance with different tool bits
Brass or aluminum case
Iron
Rubber gasket-prevents vibrating top iron
Air(large change of acoustic impedance-hence reflection)
Brazed joint
Electrical connection for spark power
Coolant slurry from pump
Entirely filled with mercury
Brazed joint
S
N
Servo magnets for adjusting sandwich height
Nickel magnetostrictive transducer
Windings (ultrasonic power supplied here)
Velocity amplifier (cone)
Support (at quiet position)
Intricate tool bit -spark plus ultrasonic

Electric spark and ultrasonics

Ultrasonic and spark-discharge transducer, developed for Cammann Mfg. Co. of Cleveland, combines electric spark and ultrasonic action to promote rate of removing metal per kw of power used; also picks up metal chips and violently agitates them, thus giving 2 to 6-micron finish to sidewalls. Unit was developed by consulting engineer W. C. Swanker.

ULTRASONICS AIMS AT MATURITY

the record grooves, or to both at once.

Most widely used of the synthetic crystals, barium titanate ceramics must be prepolarized for use as a transducer. Use of this material permits making transducers in sheets, rods, and tubes. Gulton Industries Inc. of Metuchen, N. J. is one supplier of barium-titanate transducers.

The multiwhistle is another of this company interests. A multiple set of gas-driven whistles arrayed around a cone, the instrument emits high-intensity acoustic energy. Developed by Dr. R. M. G. Boucher of France, who recently joined Gulton as director of ultrasonics-in-air research, the multiwhistle is expected to find application in fog and smog control, industrial drying, and the production of high sound intensities in a chamber for testing jet and guided-missile components.

Cleaning

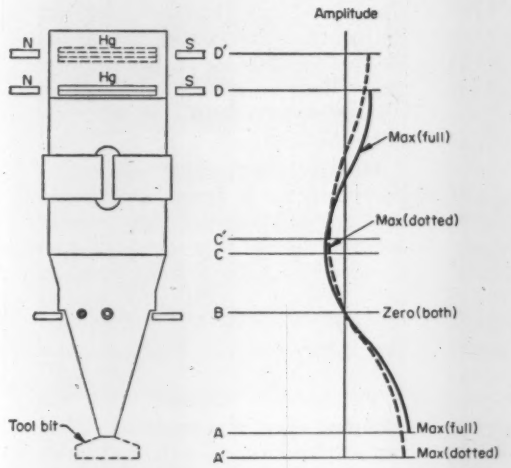
Of all commercial applications, cleaning is the bread and butter of ultrasonics. Equipment produced by various firms includes units for cleaning and degreasing anything from transistor parts to jet-engine major subassemblies.

Standard cleaning equipment ranging in volume from half a teacup to 30 gal is supplied by Bendix Aviation Corp. They also supply bigger or smaller units as custom equipment. "The big job we do is in jet aircraft," says Dr. Thomas J. Bulat of their Pioneer-Central Div. in Davenport, Iowa. "Our biggest installation is a 500-gal tank at Norton Air Force Base in San Bernardino, Calif. The unit is approximately 5 ft in diam and 4 ft high. It holds about 300 gal of fluid, and they move the large engine subassemblies in on trains, dip them in, and ultrasonically activate them."

Mass-produced Sonblasters made by Narda Ultrasonics Corp. of Mineola, N. Y., are employed for ultrasonic cleaning, degreasing, and radioactive decontamination in the electronic, ceramic, glass, chemical, automotive, aviation, heavy industry, marine, metal finishing, nucleonics, food, brewery, laboratory, hospital, jewelry, optical, watchmaking and repairing, dental, and textile industries. Also marketed by Narda are a newly developed water-wash detergent and a degreasing solvent compounded to improve efficiency of ultrasonic cleaning equipment.

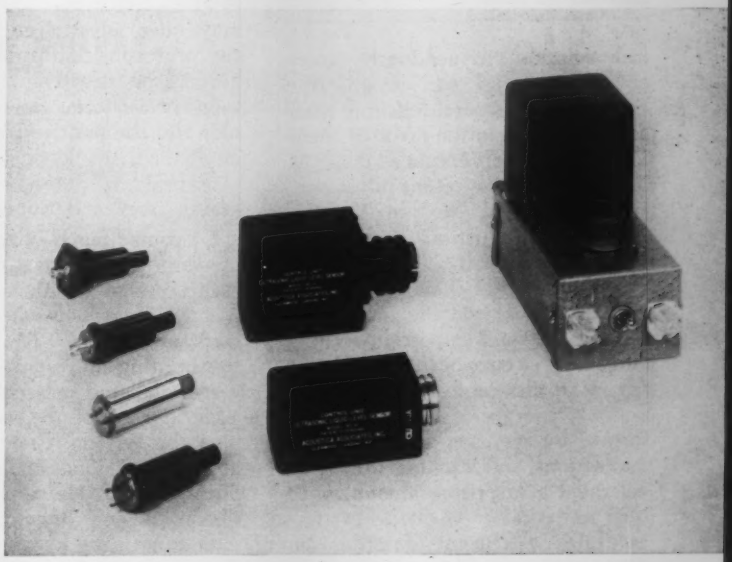
A transducerized cleaning tank, about 6 by 4 ft and 4 ft deep will be built by Alcar Instruments Inc. of Little Ferry, N. J., under contract from the Navy's Bureau of Aeronautics. The unit will be designed to clean such assemblies as jet-engine compressor rotors, turbine wheels, and combustion-chamber nozzle assemblies without teardown. A multikilowatt generator will produce vibrations to blast dirt and baked-on combustion products from the subassemblies. Ultrasonics is expected to clean the subassemblies more than 10 times faster than customary methods.

Separate ultrasonic cleaning and rinsing stages are employed in new cleaning equipment developed by Blackstone Corp. of Jamestown, N. Y. for the production cleaning of precision parts. Both the cleaning and rinsing solutions are continuously recirculated and filtered to re-



Air sandwich tunes transducer

With tool bit removed, solid line shows standing wave (resonance) occurs with reflecting air sandwich located at *D*. When heavy tool bit is attached, the driving frequency is lowered to keep support point *B* at zero. Reflecting air sandwich is then raised to *D'* to accommodate the greater wavelength. Resonance and quiet point are held stationary, despite large change of acoustic impedance caused by attaching heavy tool bit.



Sensors for missiles

Ultrasonic liquid-level sensors, used in missile and aircraft systems, indicate rise or fall of liquid past a predetermined level. From left to right are four types of the piezoelectric probe which senses acoustic damping; two transistor control units for mounting outside the liquid-filled tank, the smaller being the military version; and a mating 115-v power supply. Manufacturer is Acoustica Associates Inc.

move particles over 2 microns in size. Each ultrasonic tank is activated by two multielement magnetorestrictive transducers operating at 20 kc per sec. The equipment can be used with solvents at temperatures up to 400 F without need for water cooling of the transducers.

Machining

Ultrasonic machine tools will cut, drill, grind, and perform other machining operations on so-called "unmachinable" metals and nonmetals. A wide variety of metals such as tungsten carbide, hardened tool steels, and germanium as well as nonmetals such as diamonds, rutile, and semiprecious stones can be easily machined by this method.

In the process, developed by the Cavitron Corp. of Long Island City, N. Y., a tool is vibrated by its holder at high frequency and low amplitude. An abrasive slurry flows between tool and workpiece. Power transferred through the tool tip to the hard abrasive chips off particles of the workpiece.

Intensive development of ultrasonic machine tools is being carried on by the Sheffield Corp. of Dayton, Ohio, a subsidiary of Bendix. Grinding, slicing and dicing, surface annular grooving, and contouring of extremely fragile work are a few of the functions performed by their extensive line of machine tools.

Impact Grinder, made by Raytheon Mfg. Corp. of Waltham, Mass., employs an electromechanical transducer to convert 25,000-cps electrical current into mechanical vibrations. A shaped "tool cone" amplifies these vibrations and transmits them to the cutting tool. The cutting tool, secured to the tip of the tool cone, vibrates perpendicularly to the tool face (along the cone axis), without side-to-side motion.

A small space filled with abrasive fluid develops between vibrating tool face and the workpiece. Tiny particles of abrasive are accelerated by motion of the tool tip and are driven with tremendous impact against the work, thereby chipping or grinding an exact counterpart of the tool face into the work.

It is from this action that the term "impact grinding" is derived. The work is fed up to the tool to maintain constant grinding force between the two. Abrasive particles strike the work with impact forces up to 150,000 times their own weight, but the grinding force required seldom exceeds 10 lb. This small force, the absence of direct-tool-to-work contact, and the presence of the cool abrasive mean that impact grinding is a "cold-cutting" process.

Other applications

Heat transfer can be greatly improved by acoustic vibrations. This involves vibrating a boundary between two dissimilar materials, e.g., water and air, to provide turbulent flow at the interface. Work in speeding heat exchange has met with considerable success at Georgia Tech. There, reportedly, they have improved heat transfer by about 20 to 30 per cent without even using "special measures." Several such systems are now being built by Acoustica Associates for various processing firms.

Ultrasonic activation of a chem-

ical solution tremendously accelerates the rate of reaction, and thus can solve those metal finishing problems which are in the realm of chemical processing, Narda's Paul M. Platzman told a recent ultrasonics clinic, arranged by the Vermont Bureau of Industrial Research of Norwich University.

Acceleration of chemical reactions by ultrasonics, said Platzman, "Applies with equal import to etching, anodizing, electropolishing, and plating in an ultrasonic field. With ultrasonic energy to strip off bubbles formed by chemical or electrochemical actions, the reactions can be accelerated a surprising amount without undesirable effects. In fact, gold-plating current densities can be increased tenfold without 'burning,' and the resultant plating is mirror-smooth and practically nonporous."

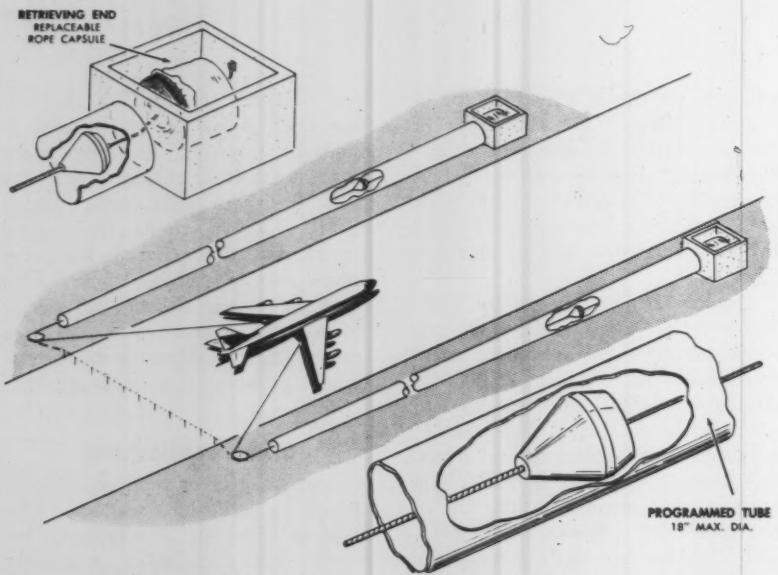
Ultrasonics creates cavitation and associated high pressures, which may offer advantages in many of the processing industries. For cavitation, the negative pressure of a sound wave forms bubbles in a liquid, and the positive pressure phase implodes them, giving rise to pressure peaks of several hundreds of atmospheres and above.

Of course much of today's developments in ultrasonics stem from earlier design of underwater equipment, such as hydrophones, fathometers, and Sonar. The principle of transmitting ultrasonic waves into a material and measuring intensity and time lag of the waves as they pass through or rebound has been applied to nondestructive testing. Such tests provide results in detecting voids and discontinuities that pass unnoted by x-rays. Hence, the two methods of testing serve often to complement each other in their range of applications.

The same principle is applied to liquid-level sensors which, instead of dropping objects to the surface of a fluid, drops sound beams instead. The sound can then be measured to the nearest half wavelength to determine the distance to the fluid surface. This may be thought of as suspending a knotted rope to determine the distance.

Ultrasonic delay lines are sometimes used as a temporary "memory" for computers. They operate on the principle that sonic or ultrasonic waves take a finite time to travel though a solid, analogous to the child's device for communication, two tin cans connected by a string.

Viscosimeters depend upon the damping effect of a medium. Placing a transducer in a fluid of given density affects the efficiency of ultrasonic transfer. The principle is used, as an example, for ice detection on airplanes. A signal transmitted to the pilot tells him that the piezoelectric crysal is loaded down, just as soon as ice begins to form.—B. D. Ross



SAFE STOP FOR BIG JETS is provided by this simple arresting engine. It's designed to stop aircraft in the weight range of 100,000 to 300,000 lb, at speeds up to 120 knots. Energy is absorbed by pulling a loose-fitting piston through a fluid-filled tube. In operation, nose wheel of the aircraft first engages a trigger cable which in turn pulls stanchions from a retracted position, lifting the arresting cable for engagement with the main landing gear. Airplane stopping distance is 300 to 1000 ft, depending on the available overrun distance. For example, a jet transport traveling at 120 knots would require about 1000 ft of runout distance, based on a peak load of 1.5 g on the landing gear. Designed and built by All American Engineering Co., Wilmington, Del., the Water Squeezer gear has been used successfully with various military planes at arresting speeds of 160 knots.

Highly Durable Metal Finish Is Painted on in One Coat

Can Replace Plating and Electro-Chemical Coloring

PHILADELPHIA, PA.—One coat of a decorative, highly durable organic finish, developed by Permatron Co., Philadelphia, Pa., will reportedly eliminate the need of plating and electro-chemical coloring on a wide variety of metals.

Permatron finish, available in gold, copper, bronze, and other colors, is applied by spraying, dipping, or roller coating. After the finish is applied to any chemically clean, polished metal, it is baked at temperatures between 325 and 400 F for about 10 min.

The company reports tests of the new finish reveal these qualities:

- It is not affected by salt spray.
- Withstands repeated impact without chipping or flaking.
- Can be post formed.
- Retains luster indefinitely.
- Unaffected by temperatures from 0 to 675 F.
- Resistant to soaps, detergents, alkalies, and acids.

Uses expected for the new finish include automobiles, aircraft, hardware, and instrumentation.

Unbiased recommendations

FRICTION or FLUID DRIVES

Manual, Air or Hydraulic Operation

To couple an engine or motor to the load, one of the following may be used: a friction clutch, fluid coupling, single-stage torque converter or a three-stage torque converter. Twin Disc can furnish you an unbiased recommendation as to which is the best selection under any given set of circumstances—for Twin Disc offers *all four types of drives.*

No other company builds the diversified line manufactured by Twin Disc. Industrial clutches are offered from 2½ to 36 inches in diameter. Designed to run wet (in oil) or dry, these clutches can be actuated mechanically, hydraulically or with air.

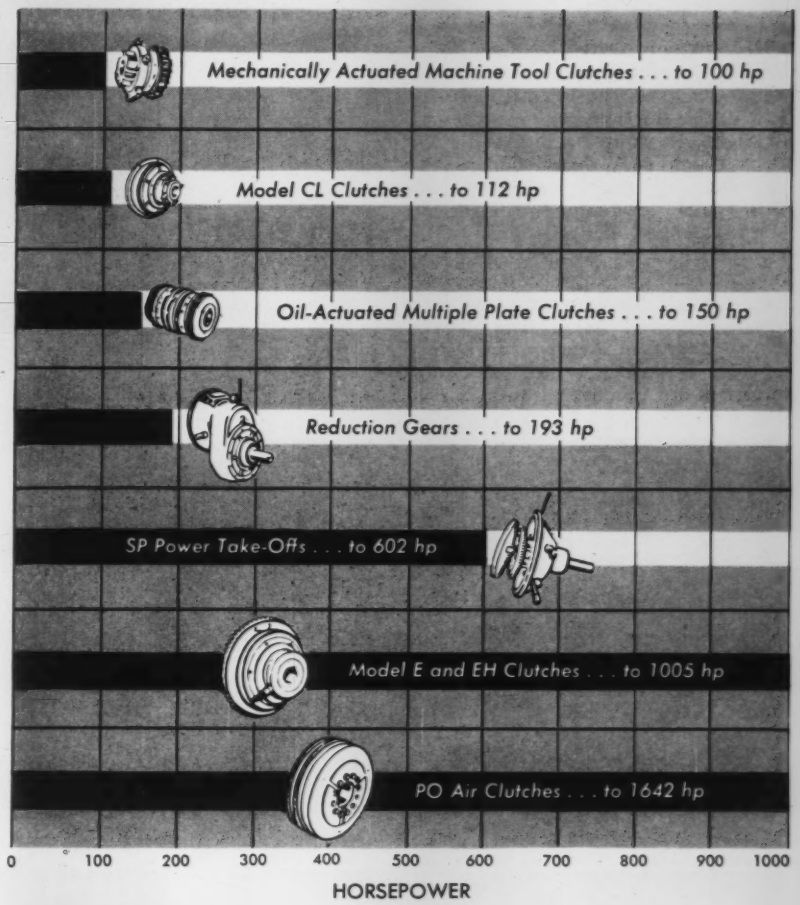
When a fluid drive is necessary or preferable, Twin Disc can recommend just the right one. Twin Disc offers fluid couplings with 1:1 torque ratio . . . single-stage torque converters with up to 3:1 torque multiplication . . . *or* three-stage torque converters with torque ratios up to 6:1. No other manufacturer builds both three-stage and single-stage torque converters . . . no other manufacturer can offer *all three types of industrial fluid drives!*

Whatever drive—friction or fluid—is most appropriate for your own particular application, you'll find it in the Twin Disc line. Write for complete information.

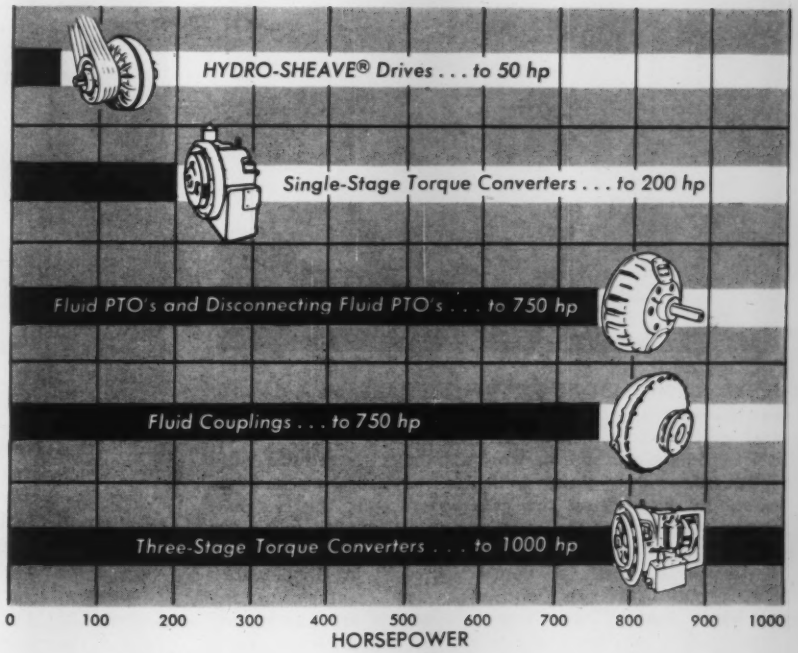
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY
Racine, Wisconsin
Hydraulic Division, Rockford, Illinois

FRICTION DRIVES


Mechanically Actuated Machine Tool Clutches . . . to 100 hp
Model CL Clutches . . . to 112 hp
Oil-Actuated Multiple Plate Clutches . . . to 150 hp
Reduction Gears . . . to 193 hp
SP Power Take-Offs . . . to 602 hp
Model E and EH Clutches . . . to 1005 hp
PO Air Clutches . . . to 1642 hp
0 100 200 300 400 500 600 700 800 900 1000
HORSEPOWER

FLUID DRIVES


HYDRO-SHEAVE® Drives . . . to 50 hp
Single-Stage Torque Converters . . . to 200 hp
Fluid PTO's and Disconnecting Fluid PTO's . . . to 750 hp
Fluid Couplings . . . to 750 hp
Three-Stage Torque Converters . . . to 1000 hp
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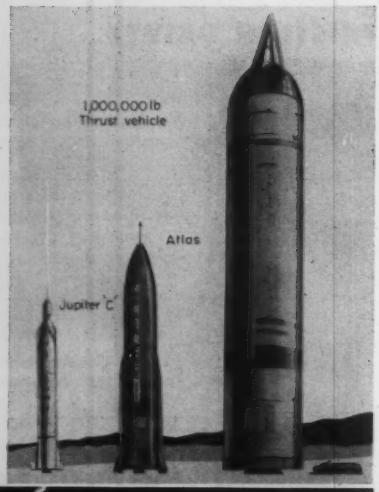
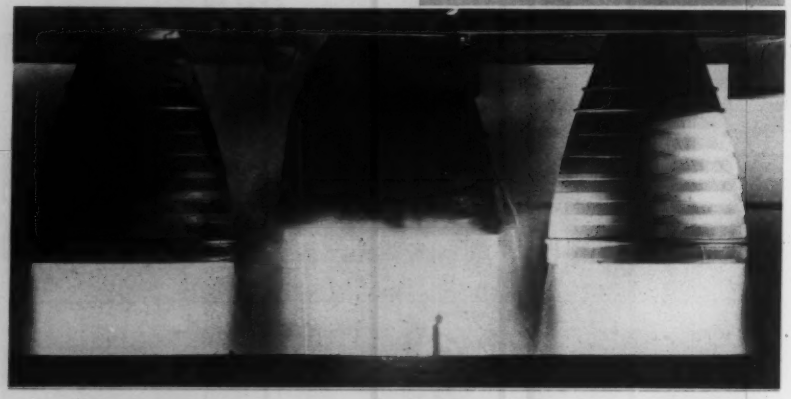
HORSEPOWER

Circle 414 on Page 19



ATLAS POWERPLANT, below, will soon be dwarfed by 1,000,000-lb thrust engine now under development. Relative size of missile that will utilize the new engine is shown at right. In contrast to Atlas system, which uses three combustion chambers to produce 370,000 lb thrust, the new engine will be of single-chamber design. This will permit relatively easy assembly of a multi-engine propulsion system for a huge interplanetary vehicle. According to Rocketdyne Div., North American Aviation, a cluster of six engines for 6,000,000 lb thrust is not out of the question.

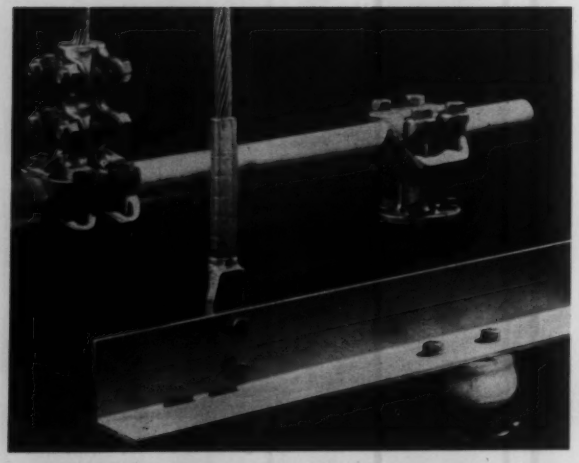


National Academy of Sciences Names Space Science Board

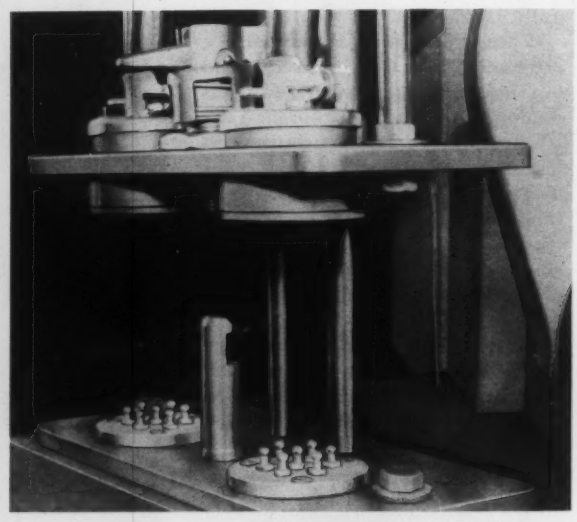
WASHINGTON—Space science board "to survey in concert the scientific problems, opportunities, and implications of man's advance into space," has been named by the National Academy of Sciences. The 16-man board, headed by Dr. Lloyd V. Berkner, president of Associated Universities Inc., will act as focal point for all Academy-Research Council activities connected with space-science research, and will coordinate its work with appropriate civilian and government agencies.

Eleven committees have been organized. Committee areas of interest range from immediate problems to future engineering development beyond available facilities.

Dr. Berkner, observing that U. S. space science should be developed on "a broad base," said " . . . we shall encourage the participation of scientists from universities and private research institutions. While government participation is essential, we feel that it would be unwise if space science were to be developed entirely within the bounds of government activity."



NEW ANGLE IN BUS CONDUCTORS, an L-shaped extrusion, will adapt to normal cable lug connectors and minimize the use of fittings. Designed by Alcoa, it's made of aluminum. Comparison with tubular bus conductor is shown above. To simplify installation, two extruded grooves on the outer surface of the bus locate center points for holes that will receive a standard connector. Single groove on inner surface locates centerline for hole to connect directly to insulators. Single conductor can be used in applications ranging to 1300 amp. Where two conductors are used and separated ¼ in., current rating is increased 70 per cent.



SELF-ALIGNING CONNECTOR permits connecting and disconnecting electrical equipment in a radioactive room by a mechanical manipulator. A conventional plug could not be used because of close tolerances; also, if pins should be damaged, plug would be inoperable. New type of self-aligning connector, designed on a two-ball-and-socket principle by Cole Electric Co. of Culver City, Calif., is used in Atomics International hot cell. It compensates automatically for misalignment.

Circle 415 on Page 19→

HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW

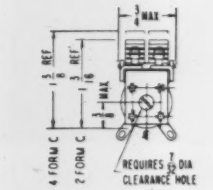
Shown with printed circuit terminals

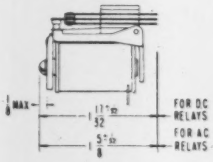
VERSATILITY and adaptability

are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required... when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.





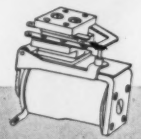
ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.
Insulation Resistance: 100 megohms minimum.
Breakdown Voltage: 500 volts RMS between all elements.
Shock: Up to 30g.
Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.
Ambient Temperature: −45°C. to +85°C. −(65°C. to +125°C. on special order).
Weight: 2½ oz. max. (open relay)
Pull-In: Approx. 75% of nominal voltage.
Pull-In Speed: Approx. 15 ms.
Drop-Out Speed: Approx. 10 ms.
Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

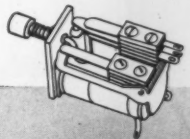
CONTACTS:
Arrangements: Up to 9 springs per stack.
Material: ⅛" silver; also Palladium or gold alloy.
Load: Dry circuits to 5 amps @115V AC resistive.

COILS:
Resistance: 22,000 ohms max.
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.
Current: 2.5 ma to 10 amps DC.

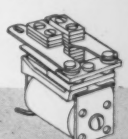
P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



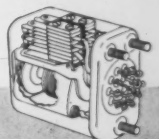
MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



MA LATCHING
Electrical latch; mechanical reset. Small, versatile and offered with selection of contact arrangements.



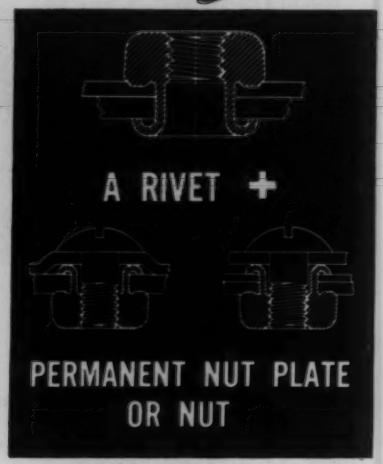
MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

POTTER & BRUMFIELD INC.
PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

ORIGINATED by TRS



USE THIS NEW HELPER in scores of ways. It offers unique advantages to mass production . . . not only can you set it with a simple TRS tubular rivet setter but also with a TRS automatic feeding and setting machine. Perma-Nuts are strong . . . head thickness is greater than width across flats of standard nuts. From 3 to 4½ clean threads provided. Serrations under head lock nut tightly in position. Available in a range of sizes; made of steel, brass, aluminum.

TRS® TUBULAR RIVET & STUD CO.
Quincy 70, Mass.
Branches in major industrial centers

Send Perma-Nut samples and data bulletin

Name, Title .....

Company .....

Address .....

. . . . . .

Circle 416 on Page 19

Cockpit for Mach-5 Aircraft Marks New World for Pilots

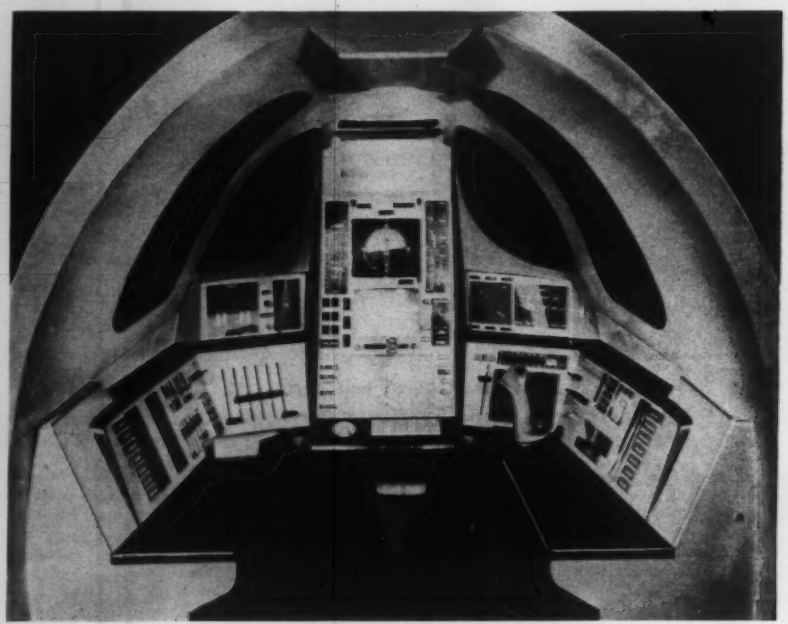
GRAND RAPIDS, MICH.—A full-size cockpit mock-up designed by Lear Inc. for a Mach-5 aircraft was delivered to Wright Air Development Center early this month to support the USAF-WADC Whole Panel Study and Development Program. Called the Mark III, the cockpit is based on the pilot-manager concept —routine tasks are performed either by automatic devices or by the crew. The pilot is given basic and summary information from which he can make fast, management decisions.

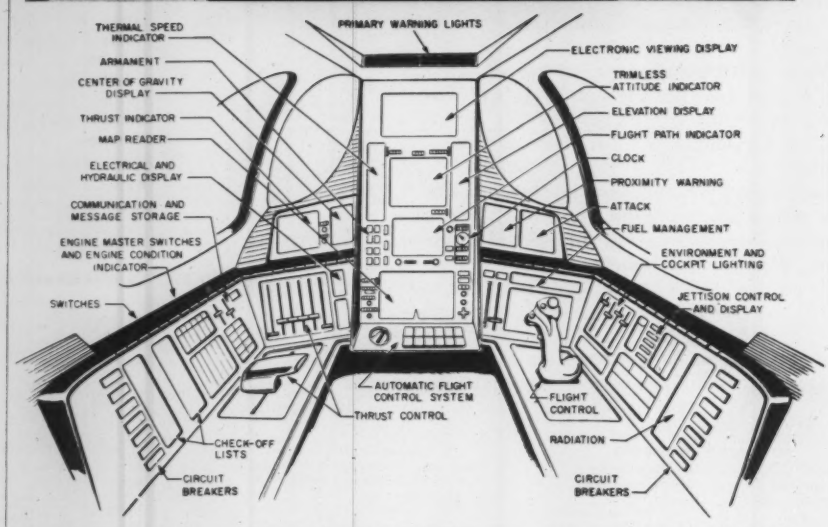
Each display in the new cockpit is arranged according to the pilot's need. Vital or emergency information is displayed in the center panel, directly in front of the pilot, with less frequently used dials, indicators, and switches to the right and left.

According to Lear engineers, management of a high-performance vehicle is divided into three major areas: 1. Spatial translation, 2. machine condition, and 3. environment.

Spatial Translation

Lear innovations include an electronic viewing display—a TV camera mounted in the plane's vertical stabilizer, with display on the main, center cockpit panel. This would permit pilot to inspect engine, wing

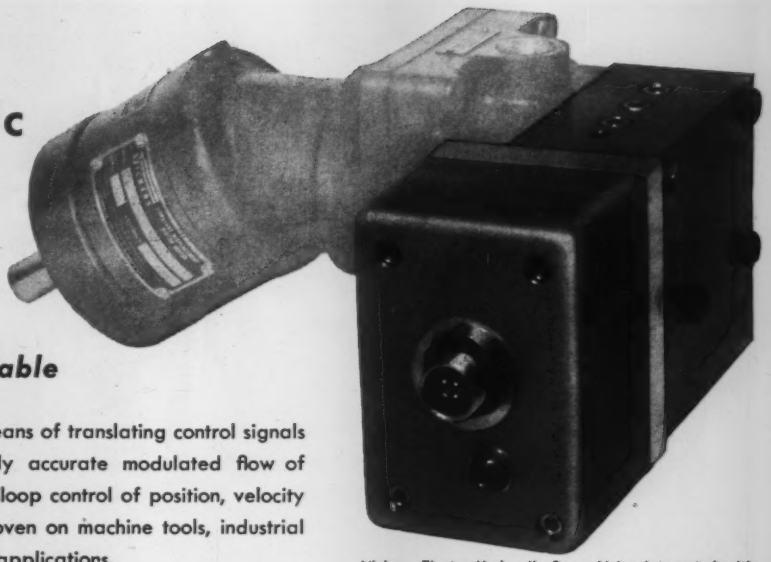




New VICKERS® Electro-Hydraulic Servo Valve

has numerous advantages for industrial use:

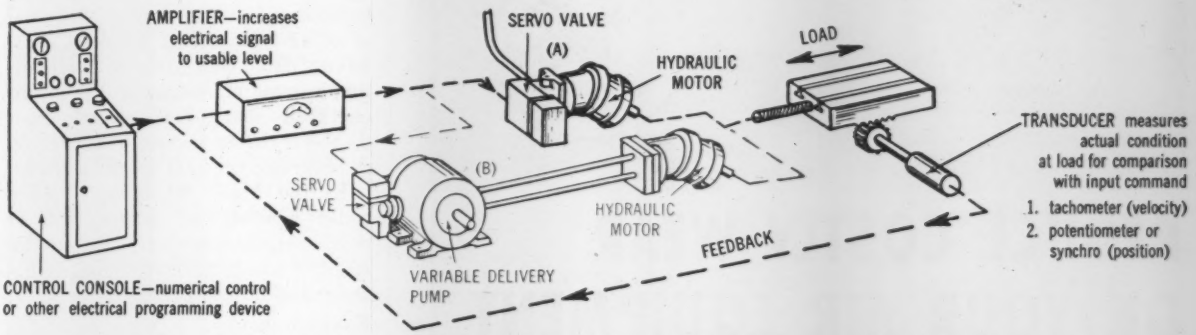
- ***Extremely Accurate***
- ***Simple • Rugged • Dependable***



Vickers Electro-Hydraulic Servo Valve integrated with piston type hydraulic motor provides a minimum amount of oil under compression. Integral cross line relief valves are provided as well as variable cross line orifice for controlling viscose damping. This "package" can provide approximately 20 hp @ 3000 psi and 3600 rpm; variable speed of motor is 0-4400 rpm.

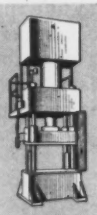
This valve provides a simple, dependable means of translating control signals from electronic programming into extremely accurate modulated flow of hydraulic power for fast and precise closed loop control of position, velocity and acceleration. Performance has been proven on machine tools, industrial processing equipment and ground ordnance applications.

Simplicity and reliability are exceptional . . . only four moving parts are required. Mechanical feedback linkage with unique variable fulcrum provides optimum flexibility for various conditions of flow, response and pressure. For further information, write for Vickers Engineering Bulletin 58-74.

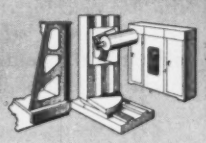


Now the flexibility of electronic control can easily be applied to versatile hydraulic power. Vickers new industrial electro-hydraulic servo valve is used (A) to directly regulate the oil to an actuator (valve motor system). Shown in blue is an alternate application (B) for higher flows when the valve controls a variable volume pump (servo pump system).

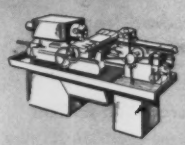
REPRESENTATIVE SERVO VALVE APPLICATIONS



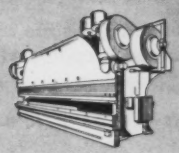
PRESS
Ram velocity controlled accurately during all cycles.



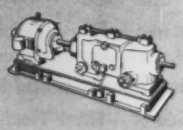
MILLING MACHINE
Precision control of velocity, position and acceleration of slides and tables.



LATHE
Exact feed rate and position control of cutting tool.



PRESS BRAKE
Cylinders synchronized precisely.



VARIABLE SPEED DRIVE
Accurate velocity control of spindle speeds for test stands or machine tools.

PROCESS LINE
Programmed control of Material Handling and machine sequencing.

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 417 on Page 19

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surfaces and armament as well as the surrounding area not visible from the cockpit.

Other spatial translation devices, all displayed on the center-panel screens: A time-sharing panel from which pilot could select various kinds of information which he would need only for short periods of time. This would include a takeoff-refusal indicating system; a device showing actual center of gravity versus a safe operating center of gravity; and an inflight refueling display, showing position of aircraft's probe and tanker's drogue. A map reader, tied into the inertial guidance system, would give continuous display of the area over which the aircraft was flying.

Machine Condition

A few of the devices in the spatial translation area are imaginary, but Lear-proposed instruments relating to machine condition could be converted to hardware with present technology. They include thermal overload-type circuit breakers, providing visual indication of overloading; automatic landing and preflight check-off lists; fuel management displays; thrust reverse and braking display; and thermal speed indicator.

In the Mark III cockpit, speed could possibly be determined by computing temperature readings instead of usual method of measuring static and impact pressure.

Environment

The environment panel contains proportional controls for windshield defrosting, heat, airflow, and cockpit temperature. White instrument lighting in the cockpit permits the use of color coding on displays.

To insure a safe escape from the aircraft, the entire crew capsule could be jettisoned.

Meetings

AND EXPOSITIONS

Sept. 3-5—

First National Conference on the Application of Electrical Insulation to be held at the Pick-Carter and Statler-Hilton Hotels, Cleveland. Sponsors are American Institute of

Circle 418 on Page 19

Electrical Engineers and National Electrical Manufacturers Association. Additional information can be obtained from Mr. T. F. Hart, Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.

Sept. 10-11—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N. Y.

Sept. 14-18—

American Rocket Society. Fall Meeting to be held at the Statler Hotel, Detroit. Further information is available from ARS headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 15-19—

Instrument Society of America. Thirteenth Annual Instrument-Automation Conference and Exhibit to be held at Convention Hall, Philadelphia. Additional information is available from society headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 21-24—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Cosmopolitan Hotel, Denver. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 22-23—

Steel Founders' Society of America. Fall Meeting to be held at The Homestead, Hot Springs, Va. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 22-24—

Institute of Radio Engineers. National Symposium on Telemetering to be held at the Americana Hotel, Miami Beach, Fla. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

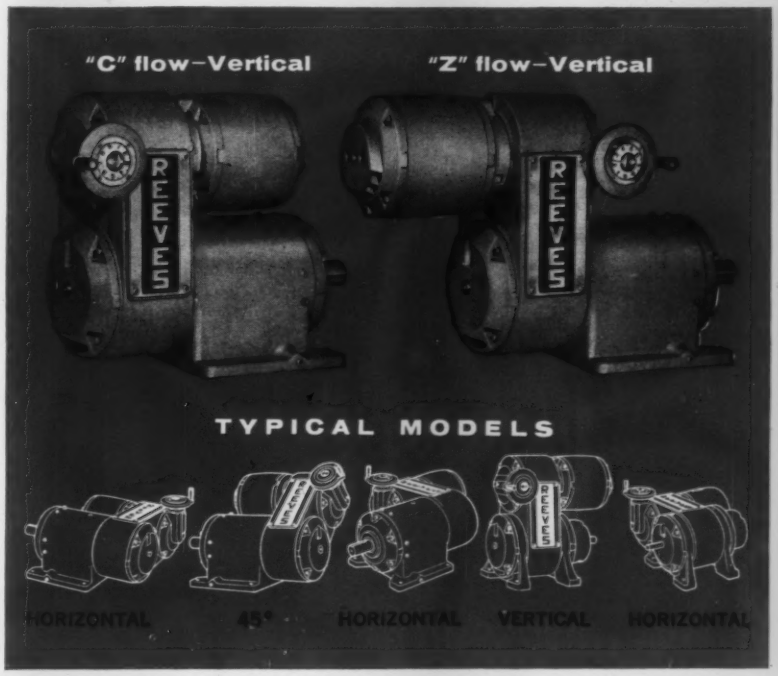
Sept. 22-24—

Standards Engineers Society. Seventh Annual Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from Mr. C. W. Bowler,

NEW **REEVES**®

*Sizes 200-300-400 Vari-Speed MOTODRIVES**

* *200-300-400 Sizes, 1 through 10 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300-400 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. H32d-M571.

REEVES PULLEY COMPANY

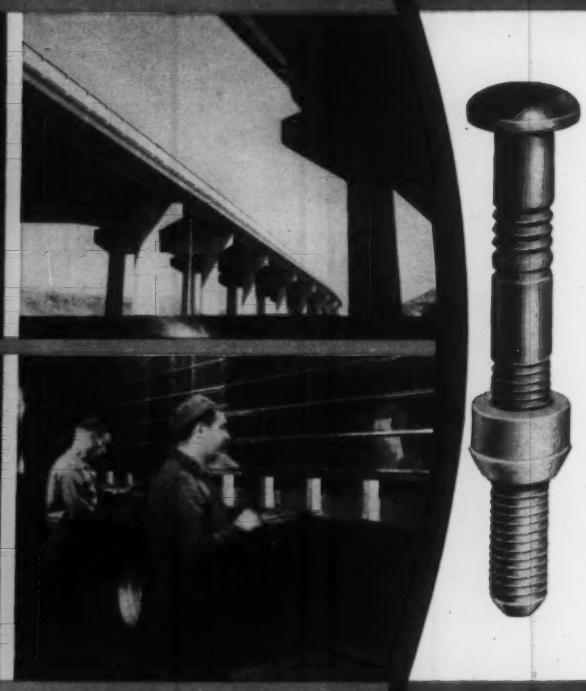
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 419 on Page 19

when Fabricating Aluminum

increase strength and beauty . . .



cut production costs . . .

with Townsend Aluminum Lockbolts

Appearance is improved, since the aluminum lockbolts* match the material being fastened. Joints are neat—there is no roughness or weld-splatter, no tool marks, no rust streaks after exposure to weather.

Lockbolts will not alter the mechanical values of the material being fastened, and their high tensile pre-load values are uniform. These two factors make design calculations simpler and more accurate.

Townsend aluminum lockbolts can lower your production costs, because operators with no special skill or training can make strong, uniform joints at high production rates. The setting guns are designed to eliminate the possibility of human error.

If you are fastening aluminum, investigate the advantages of Townsend lockbolts. Write for Bulletin TL-101. Townsend Company, P. O. Box 237-E, New Brighton, Pa.

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

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Sept. 22-24—

Material Handling Institute Inc. Fall meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 23-26—

Association of Iron and Steel Engineers. Iron and Steel Exposition and Convention to be held at the Public Auditorium, Cleveland. Further information can be obtained from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 24-25—

Seventh Annual Conference on Industrial Electronics to be held at the Rackham Memorial Bldg., Engineering Society of Detroit, Mich. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Additional information can be obtained from Mr. H. W. Patton, Acromag Inc., 22519 Telegraph Rd., Detroit 41, Mich.

Sept. 25-27—

Porcelain Enamel Institute. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Further information can be obtained from PEI headquarters, 1145 19th St., N. W., Washington, D. C.

Sept. 29-Oct. 3—

Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at the Ambassodor Hotel, Los Angeles. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 29-Oct. 3—

American Society of Tool Engineers. Semiannual Meeting and Western Tool Show to be held at the Shrine Exposition Hall, Los Angeles. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

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Oct. 8-10 —

Industrial Designers Institute. Design Materials Show to be held concurrently with the annual National Conference of IDI at the Sheraton-East Hotel, New York. Additional information can be obtained from Mr. Leonard Rogers, Orkin Expositions Management, 19 W. 44th St., New York, N. Y.

Oct. 8-10—

Gray Iron Founders' Society. Annual Meeting to be held at the Sheraton Park Hotel, Washington, D. C. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

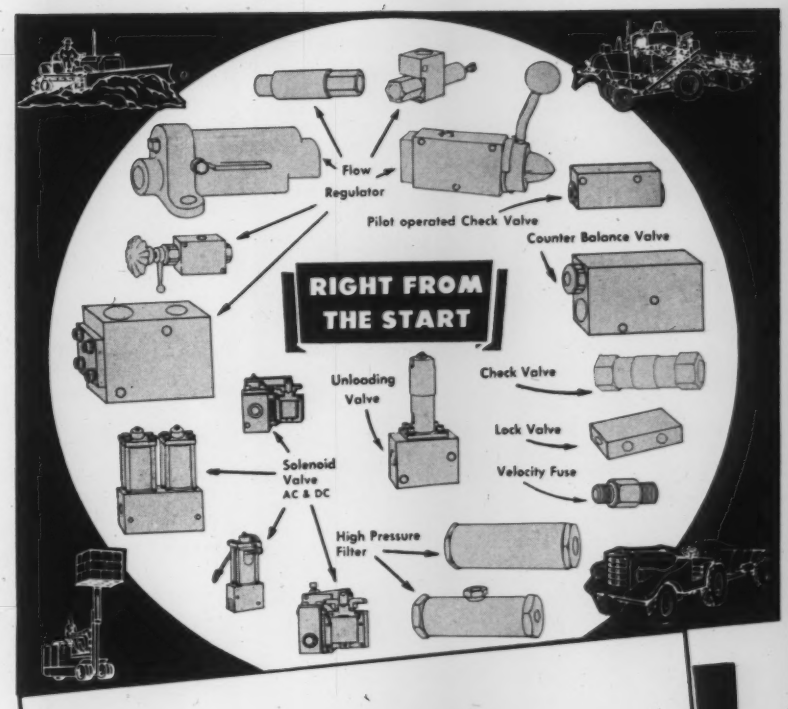
Oct. 9-10—

American Society of Mechanical Engineers-American Institute of Mining, Metallurgical, and Petroleum Engineers Inc. Fuels Conference to be held at Hotel Champlain, Old Point Comfort, Va. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

"We still have a few bugs to overcome on this solor-powered flashlight. For one thing, it works only in the daytime."

Oct. 13-14—

Fifth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Further information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.



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All of the above valves have been used in various types of applications, including Material Handling, Road Building, Machine Tools, Farm Equipment and Earthmoving.

Waterman Engineering Company has also supplied valves to the Military for Ground Support Equipment and Missile Launchers.

We invite you to send us your applications and take advantage of our experience to help analyze your problems.

Bulletins of any of these products sent on request.

Also suppliers of AN and MS Qualified Flow Rate and Volume controls to the Aircraft Industry.

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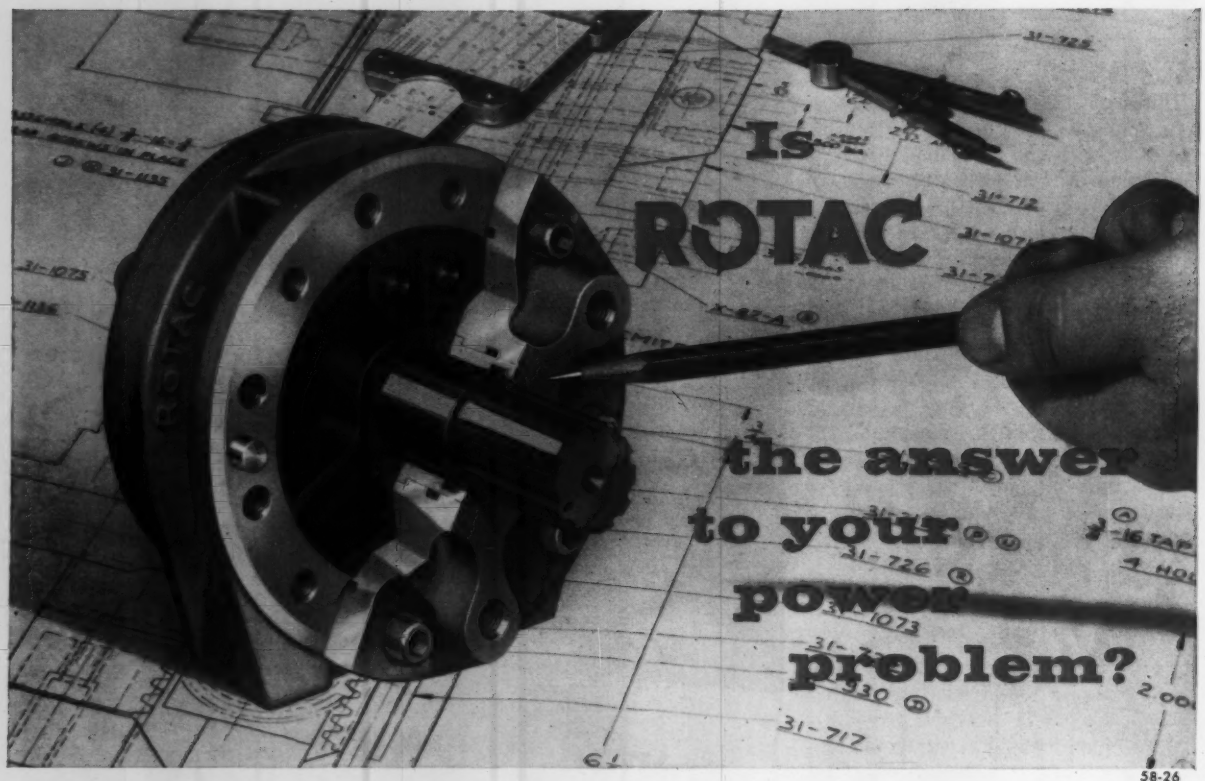

58-26

Rōtac torque actuators are simple, compact—provide positively controlled power for any movement from turning watch parts to tipping railroad cars

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained.

There is no complex linkage, no plunger action: RŌTAC's few moving parts are completely sealed from dirt and natural elements. Patented O-rings are used around vane, shoe and end caps.

RŌTAC Torque Actuators can be mounted easily—vertically, horizontally or at any angle—with the housing held stationary, or with the body rotating around the shaft.

To simplify design problems, for versatility in extended applications, specify RŌTAC Actuators for powerful, easily controlled rotary motion in compact form.

FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC — Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

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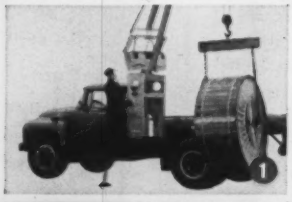
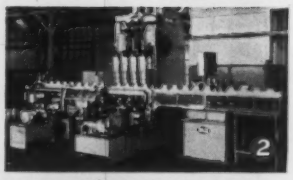
EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • TORQUE ACTUATORS • DAIRY EQUIPMENT





Just 4 of the hundreds of recent applications

1. MOBILE EQUIPMENT—A compact RŌTAC Actuator swings truck crane boom in 280° travel arc; it's controlled by a 4-way valve.

2. MACHINE TOOLS—Automation machine for boring, grooving piston wrist pin holes uses RŌTAC Actuator to orient arbors for hole alignment.

3. FOUNDRY MACHINERY—RŌTAC Actuators supply motive power for turnover of the core-box on semi-automatic shell core blower.

4. PAPER MACHINERY—Collector roll is actuated by a Model HN-63-1V RŌTAC Actuator which unloads material after slitting operation.

XLO EX-CELL-O FOR PRECISION

Circle 422 on Page 19

NEWS OF MATERIALS THAT ARE IMPROVING TODAY'S PRODUCTS

THE NATIONAL SCENE

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Nylon specialist Jack McGraw and Applications Engineering Manager Al Green discuss some of the design and economic problems related to the growing use of nylon components.

NATIONAL ANNOUNCES 5-POINT NYLON APPLICATION SERVICE

Cost Evaluation—Precision Fabrication Special Extrusions—Tubing—Stock Program

Out of a growing use of this truly mechanical plastic comes a host of special application situations. They face the man who is now using nylon. They face the man who is considering its use. Now National's "Nylon Service Program" provides a single source of information and service—from initial consultation and evaluation to product delivery.

Manned with materials specialists, like engineers Al Green and Jack McGraw (above), and backed by National's fully-staffed research laboratory, this service is proving to a growing list of customers the value of an unbiased recommendation—and services to back it up.

Everyday problems such as metal vs. nylon . . . molded vs. machined parts . . . in-plant fabrication vs. purchased parts . . . are being eased by a careful study of the facts. National can afford to be objective, since it serves industry with over 100 grades of basic engineering materials. Turn the page and see first-hand how it can work for you on nylon . . .

Circle 423 on Page 19

". . . cost . . . performance . . . or both?"

"Cost evaluation must be keyed to the established design target. In short, is nylon the answer to cost reduction . . . improved performance . . . or both? This is the stage where we prefer to tackle an application problem," points out Al Green. "While many times there is no question about changing from, say, phosphor bronze, chrome, nickel or stainless steel, hard wood, brass, copper or another plastic to nylon, just *how* that change is made usually determines the results . . . in dollars or in product performance. A change of materials often opens an opportunity for design simplification. It can lead to multiple component changes . . . or an unusual use of combination-materials. It is at this point—preliminary cost evaluation—where we can generally contribute most."

"Economy evaluation of the decision to mold a nylon part or machine it is not as clear-cut today as it once may have been. Piece volume and complexity of design crop up most often as a basis for decision. But we know from experience that there are no hard and fast rules.

". . . look before you mold . . ."

We do know that it's a lot easier to change a screw machine setting than it is to make new molds. By and large new products go through many refinements and changes during the first year or two. Here the flexibility of machining over molding can become a real dollar factor. Once the design is stabilized, a shift to molded parts may be clearly indicated." Summarizes Green, "if we have any rule of thumb it amounts to 'look before you mold'."

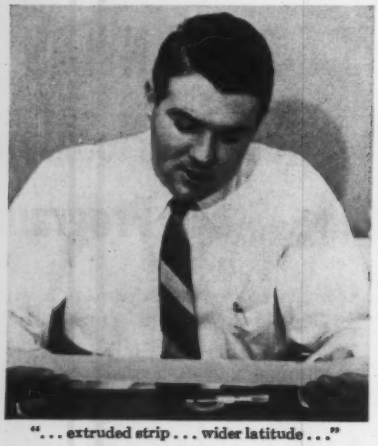
"Fabrication of precision components from special extruded shapes," explains McGraw, "is getting a lot of interest today, particularly where time in meeting the design schedule is critical. And

". . . components from special shapes . . ."

again where there are a number of modifications to the same basic component. The idea, of course, is to extrude a special shape, then machine the final design details. This can be as simple as cutting bearings from an extruded tube or bearing slides from an I-shape extrusion.

From a customer standpoint, this technique offers several advantages, particularly to those who prefer to do their own fabricating but wish to capitalize on the economies of working with a special shape.

"Extruded strip we are now making, offers similar design and production advantages. The fact that nylon can be

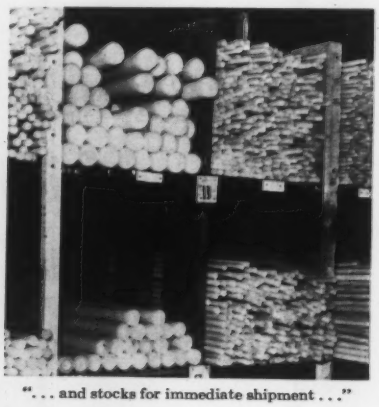


". . . extruded strip . . . wider latitude . . ."

". . . nylon tubing . . . boon to designers . . ."

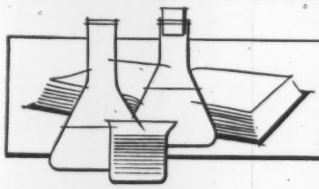
punched, swaged, drilled and tapped permits the efficient use of multiple machining operations to produce precision parts. Current uses include baseplates and a variety of bearing surfaces in electro-mechanical applications. We are now furnishing extruded strip up to 7 inches wide which gives the user considerable latitude."

"Extruded tubing has become a real boon to equipment designers who have had to design around the limitations of metal tubing. We are furnishing tubing for both pressure and non-pressure uses. Nylon not only handles air, gases and liquids better than most metals, but its flexing qualities permit it to be used where vibration is severe or there are tube connections in motion. The fact that nylon is light-weight and costs less per foot than many metals offers additional benefits. (See 'Out of the Labs' story). Currently, automotive, aircraft and machine tool applications are getting the biggest play. We see all kinds of other possibilities—the instrument field for one. And as soon as the cost advantages in assembly line production and field installation of nylon over metal tubing are fully recognized, there will be plenty more."



". . . and stocks for immediate shipment . . ."

For specific help in evaluating your nylon application, use the handy coupon.



OUT OF THE LABS

Bringing new products from the experimental stage to full-scale production is another of the important functions of National's Research and Development Laboratory. Here, testing and study become the first step in quality control.

Case in Point: Nylon tubing for pressure and non-pressure uses. New techniques and equipment had to be developed to maintain required tolerances on a production basis. National's engineers designed special dies and shape retention devices to meet required standards. Burst tests, as shown here, were used extensively to check for porosity and inclusions, as well as burst strength of the tubing. Tests were helpful in verifying the especially-designed extrusion dies and devices.

This important work adds an extra measure of performance reliability wherever National Nylon tubing is applied.

Proof pressure testing of ¼" O.D. nylon tubing to determine quality and burst pressure.

Properties: Air, gas and liquid lines are all practical applications for nylon pressure tubing. Characterized by its toughness, durability and abrasion resistance, nylon tubing is also resilient enough to withstand sudden impact blows without reducing the tube cross-section. It is suitable for continuous service over a temperature range of from —60°F to 180°F. And its excellent flexing properties make it particularly suitable for applications where vibration is severe or there are connections in motion. Nylon tubing is also chemically resistant to hydrocarbons, oils, greases and is inert to most solvents and alkali solutions.

Advantages: Nylon tubing is not only lighter in weight but also lower in cost per foot than many types of metal tubing. It is furnished in continuous lengths and can be used with standard flare or compression fittings. Its flexibility permits nylon tubing to be bent around existing equipment, reducing production time and eliminating numerous fittings.

Availability: National Nylon pressure tubing is available in standard sizes ranging from ⅛" O.D. through ⅜" O.D. in two types. Type MB (Medium Burst) has a tested burst strength of 1000 psi; Type HB (High Burst), 2500 psi. National Nylon Type F-1 (Flow) tubing is available for non-pressure applications in sizes from .064" O.D. through .259" O.D. For specific application information, use the coupon on the right.

National Maintains Stocks for Immediate Delivery

Whether your need is Nylon, Vulcanized Fibre, or PHENOLITE Laminated Plastic, National carries full stocks of most standard grades in a number of sizes and thicknesses. For prompt action, call:

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Boston	TWinbrook 4-3500
Chicago	AUstin 7-1935
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SERVICE AND INFORMATION

If you have a nylon application in mind, use the space below for prompt help. No obligation of course.

I would like to discuss an application of nylon to.....

.....

.....

.....

For more detailed comparison and selection information on National's *full line* of basic materials, or details on National's fabricating services, send for the literature described below.

☐ **A. Materials Selection Guide 16 p.**

☐ **B. Fabricated Parts Booklet. 8 p.**

NATIONAL VULCANIZED FIBRE CO.

Dept. NSG-8, Wilmington 99, Del.

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

CITY.....ZONE....STATE.....

Circle 423 on Page 19

HOBART EXECUTIVES (left to right) Robert B. Bravo, Sales Manager, Power Equipment Division; Byron A. Lutz, Director of Purchasing, All Divisions; Roger L. Frantz, Design Engineer, Power Equipment Division. Background, new "Power-Pull" Model 871 Hobart self-propelled ground power unit with Chrysler Ind. 56A V-8 engine.

why Hobart powers with Chrysler Industrial Engines

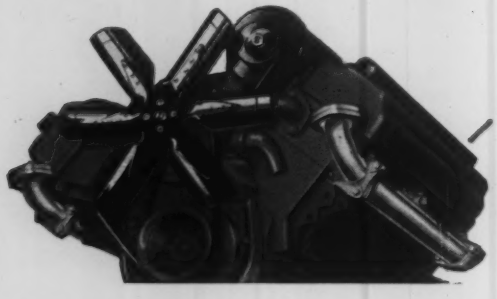
Hobart mobile ground power units are used by commercial and military airports and by aircraft manufacturers all over the world. They supply auxiliary electrical power to planes on the ground, start the plane's engines when it is ready to take-off. Two of the four Hobart models also double as towing tractors.

Demands on the engine are varied. Chrysler Ind. 56A, for example, must drive a generator at 1800 rpm's, delivering 1000 amps for continuous duty; 1250 amps for three-minute intermittent service. It must turn a jet aircraft engine up to 3000 rpm's for starting. It must operate efficiently at low speeds as well as high speeds; it must operate dependably in the frigid winters of Alaska as well as the torrid heat of Africa.

Hobart has found that Chrysler Power meets demands more efficiently, more economically and with less maintenance than any other engine manufactured—and at lower initial cost. In fact, Hobart estimates that any other engine capable of the job would cost at least 30% more and even then, could not equal Chrysler maintenance records.

HOBART MOBILE POWER UNITS come in four models; Hobart 871 powered by Chrysler Ind. 56A; Model 666, Model 869, Model 595 powered by Chrysler Ind. 32. Hobart 871 and Super 666 are built to serve as aircraft towing tractors as well as mobile power units.

SEND FOR 1958 CHRYSLER INDUSTRIAL ENGINE CATALOG: Dept. B8, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.



Chrysler
INDUSTRIAL ENGINES
INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION

Typical of K-30 application is this two-piece sealing ring design with K-30 outer ring and cast iron or stainless steel inner.

Licks tough ring problems

Proven Applications

★ Non-Lubricated Compressors: air, nitrogen, oxygen, hydrogen and carbon dioxide.

★ Rotary Shaft Seals: corrosive and non-corrosive surface.

★ Miscellaneous: sealing rings wearing directly against aluminum cylinders, wear bushings, wear inserts, and plug-type pistons.

Wide Range of Sizes and Types

Koppers K-30 piston, wear and sealing rings may be made in all widths and diameters—for use with cast iron, stainless steel, aluminum or chromium-plated cylinders.

Radical, rugged Koppers K-30 gives you new operating economy and long-lived performance in applications too tough for ordinary piston and sealing ring materials. K-30, a special compound of TEFLON* with other wear-resisting materials, features:

★ *Low friction coefficient* – inhibits ring wear.

★ *Self-lubrication* – reduces cylinder wear.

★ *Zero water absorption* – means that it cannot swell or change its shape.

★ *Temperature resistance* – from a molecular structure that permits operation at temperatures from – 350° F. to 500° F.

★ *Toughness and flexibility* – eliminate breakage, scoring and other damage caused by storing, handling, installing or servicing. Permit smaller ring cross-sections and smaller piston sizes and weights.

★ *Chemical inertness* – makes K-30 corrosion-proof.

If you have a ring problem, put Koppers to work on it. Contact your nearest Koppers Representative or write KOPPERS COMPANY, INC., Piston Ring and Seal Dept., 2308 Scott St., Baltimore 3, Md.

*TEFLON—trademark of E. I. DuPont de Nemours & Co. for tetrafluoroethylene resin.

KOPPERS

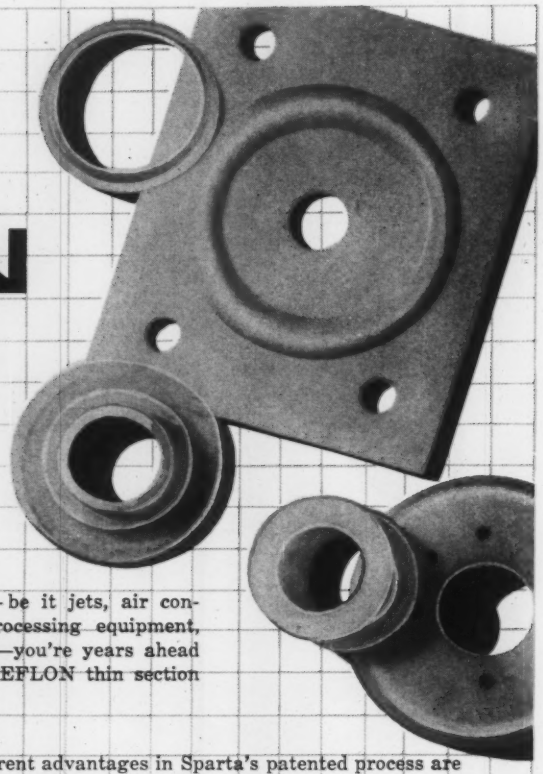
INDUSTRIAL PISTON AND SEALING RINGS

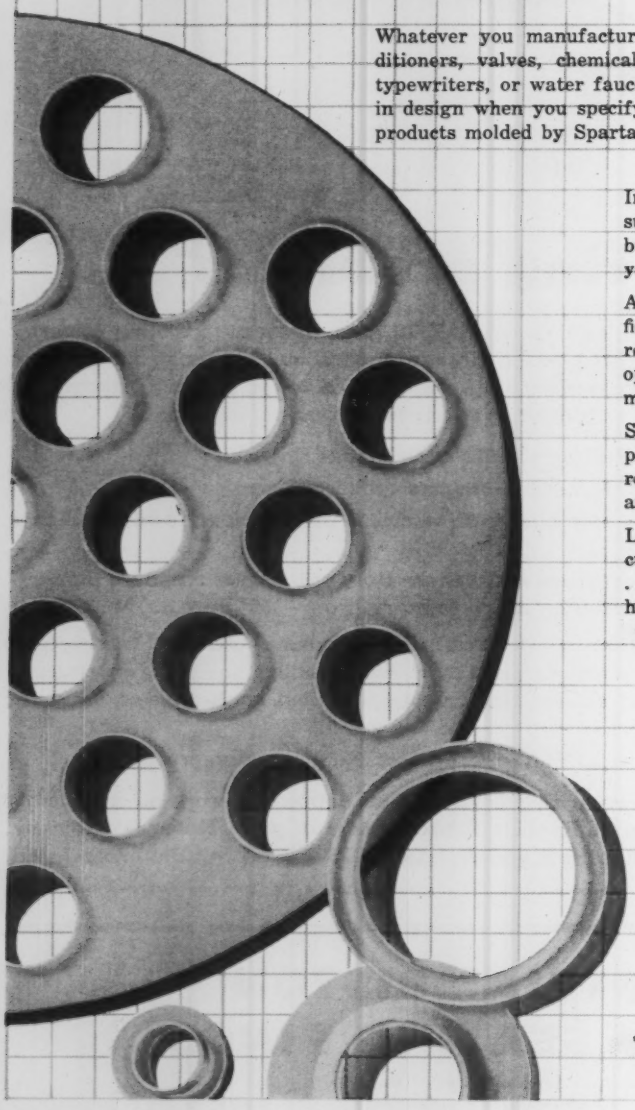
Engineered Products Sold with ***Service***

Circle 425 on Page 19

SEAL YOUR DESIGN

with TEFLON* THIN SECTIONS by SPARTA custom molded to your precise specifications





Whatever you manufacture — be it jets, air conditioners, valves, chemical processing equipment, typewriters, or water faucets—you're years ahead in design when you specify TEFLON thin section products molded by Sparta.

Inherent advantages in Sparta's patented process are superior physical properties, product uniformity and built-in memory for more positive sealing, assuring you better all around performance.

And you save on production costs through a simplified design, reduced material costs, minimum labor requirements, elimination of expensive machining operations and greater design tolerances for all mating component parts.

Sparta engineers will work with you in designing parts molded from compounded Teflon to meet your requirements of less cold-flow, increased wear life and dimensional stability.

Learn how Teflon thin sections are helping others cut costs, design better and improve performance . . . write today for information and typical case histories. Dept. MD.

SPARTA MANUFACTURING CO.

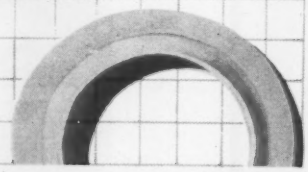
DOVER, OHIO • Phone: 4-2380

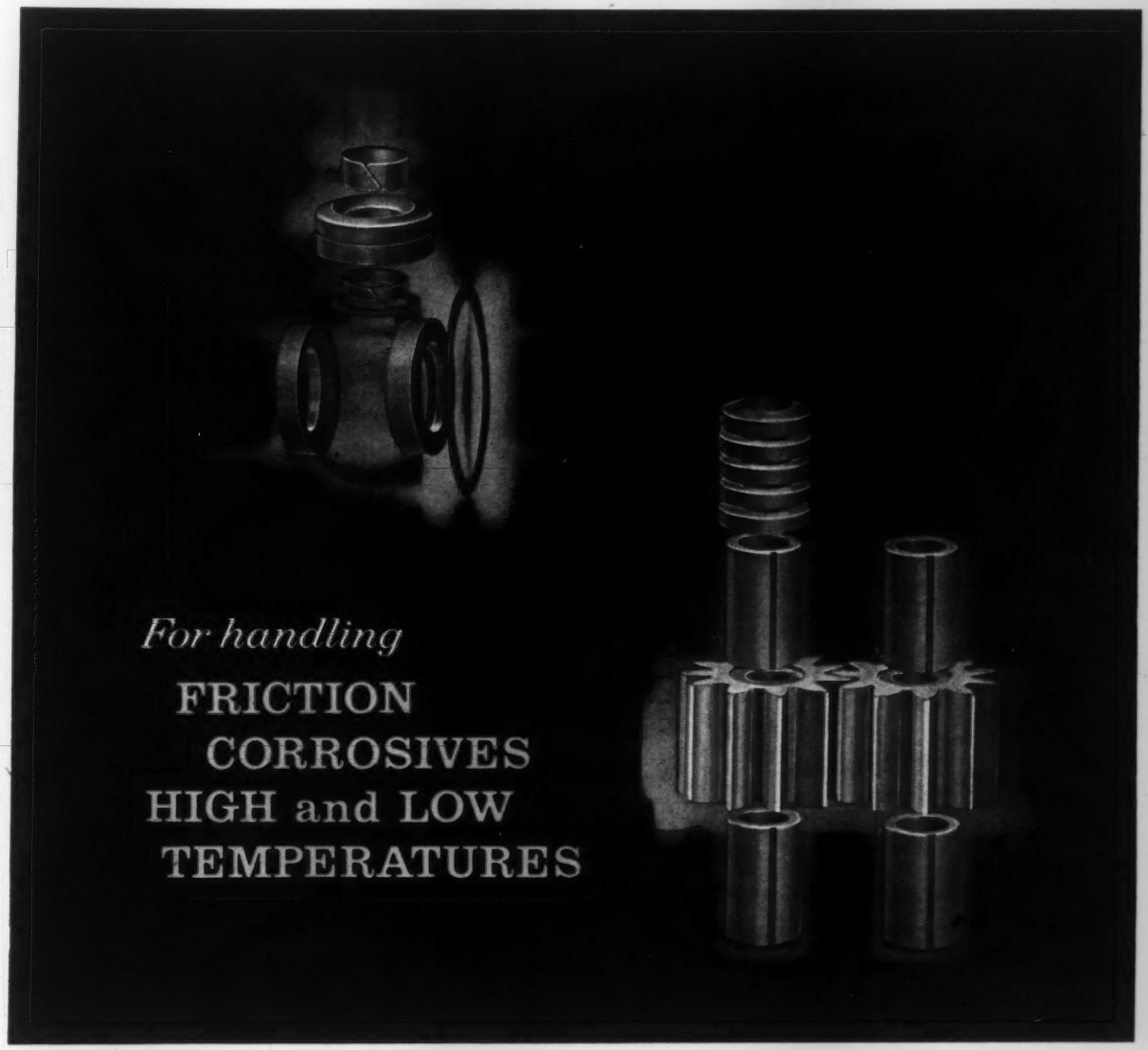
FABRICATORS OF **TEFLON PRODUCTS**

DIVISION OF UNITED STATES CERAMIC TILE COMPANY

WESTERN OFFICE:
6460 Corvette Street
Los Angeles 22, California
Phone: PArkview 2-2196

*Dupont's TFE Fluorocarbon Resin





X-RAY photos show typical uses of Du Pont TFE resins . . . seals in chemical valve and bearings in gear pump.

Here's why seals and bearings of TFE-fluorocarbon resins may be your solution

TFE-fluorocarbon resins have the lowest coefficient of static friction of any solid substance known. Under high loads, coefficients lower than 0.016 have been measured. The resins have practically universal chemical inertness and are rated for continuous use at temperatures from —450° to 500°F.

TFE BEARINGS can operate dry in assemblies where lubrication is difficult or impossible. *As in the pump shown above, which handles hydrogen peroxide, ethylene oxide, hydrazine, they* perform unharmed and keep products free of contamination by lubricants. TFE bearings can be tailored for high loads, high velocities or high wear resistance by the use of reinforced constructions.

TFE SEALS are not damaged by vicious chemicals or temperature extremes. *As in the valve shown above,* their low surface friction makes for low torque, easy operation, perfect release from metallic contact. TFE fluorocarbon seals are available in all basic designs and configurations.

DISCOVER how you can improve your products and processes with seals and bearings of Du Pont TFE-*fluorocarbon* resins. For product *and design* information see your local supplier. Look *for him* under "Plastics--Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room MD2524, Nemours Building, Wilmington 98, Delaware.** In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.

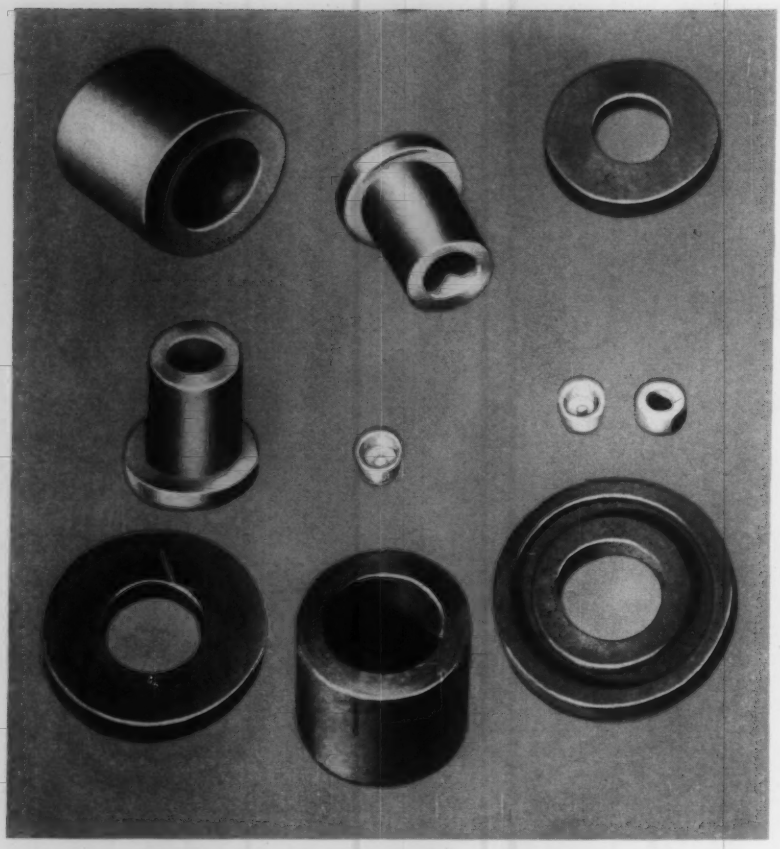
DU PONT
REG. U.S. PAT. OFF.

TEFLON®
TFE-FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Circle 427 on Page 19



COMPLETE BEARING SERVICES

Chemical & Power Products offers complete Filled Teflon Bearing services including:

1. Chempro finished bearings, machined with correct interferences, tolerances and complete installation instructions.

2. Chempro finished bearings, pressed into stainless steel, bronze or carbon steel housings, ready for installation.

3. Chempro molded tubes of Filled Teflon Bearing Materials for machining finished bearings in the customer's own shop. Sufficient material will be available for finish machining. Complete machining instructions will be furnished, as well as interferences, tolerances and clearances of finished bearing, and accepted methods of retaining the bearings in the housing.

CHEMPRO
FILLED TEFLON* BEARINGS

Chempro Filled Teflon Bearings are widely used as radial bearings on vertical pumps, tail shaft bearings on reactors and mixers, throat bushings on centrifugal pumps, piston rings on reciprocating pumps and similar applications where a chemically inert, non-corrosive, non-contaminating and non-adhesive material is required.

Chemical & Power's line of Filled Teflon Bearing materials is composed of virgin Teflon powder filled with various materials to meet specific operating conditions. Chempro Filled Teflon Bearing materials are *made harder, more wear-resistant and less subject to thermal expansion and cold flow under thrust than pure Teflon.*

All Chempro Filled Teflon Bearings are stress-relieved at temperatures up to 385°F. to provide dimensional stability and to preclude shrinkage.

* du Pont trademark

CHEMPRO FILLED TEFLON STYLES

STYLE	MATERIAL
FM-2	Glass-Filled Teflon
FM-3	Carbon-Filled Teflon
FM-4	Glass and Carbon-Filled Teflon
FM-5	Ceramic-Filled Teflon
FM-8	Graphite- and Zircon-Filled Teflon
FM-9	Molybdenum Disulfide and Glass-Filled Teflon
FM-10	Mica- and Glass-Filled Teflon

(Samples of these materials are available upon request.)

Write for Technical Bulletin CP-558

CHEMICAL & POWER PRODUCTS, INC.
11 Broadway, New York 4, N. Y.

The Original Fabricators of Teflon Packings and Gaskets

Circle 428 on Page 19

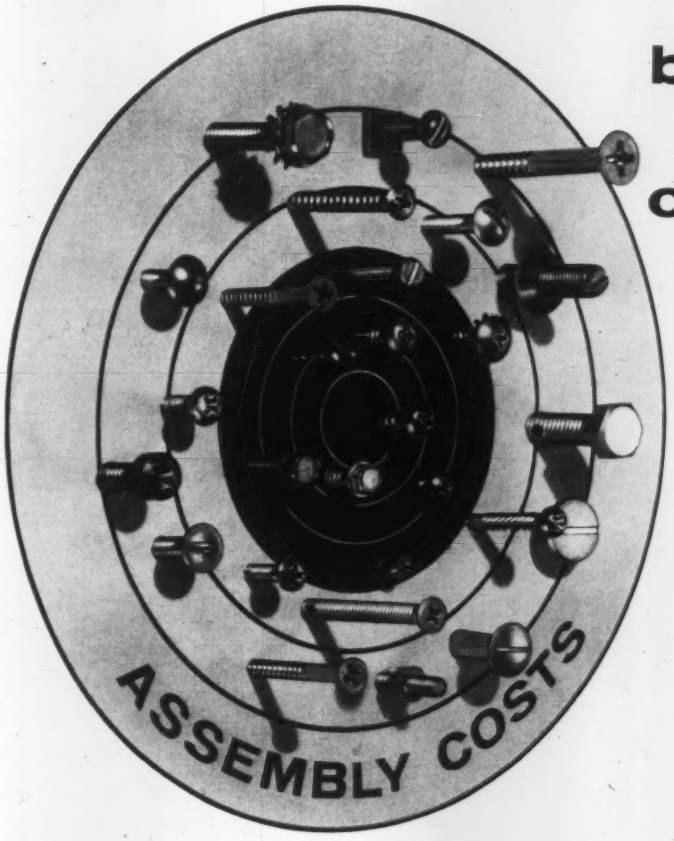
Continental can help you score more hits

on your

biggest target

for

cost reduction



Assembly accounts for up to 80% of the total cost of production. For most manufacturers, it is the biggest target for cost reduction.

If you are missing out on savings you could be making, why not get the expert assistance of Continental Assembly Specialists?

You'll find them ready and able to analyze your fastening operations and offer practical cost-saving ideas. They'll show you why assembly-men everywhere agree, ***"You can count on Continental."*** Write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

NO "FAVORITE" FASTENERS
Continental Assembly Specialists are unbiased toward any particular types . . . Continental makes all types. The fastener they recommend for your job is the one proved best by careful cost analysis.

MORE STANDARDS IN STOCK
Continental can supply any recognized standard type, style or size. Also, many fasteners ordinarily considered "specials" are available among the millions of screws constantly in stock to meet needs of Continental customers.

MORE "SPECIAL" EXPERIENCE
Continental is known throughout industry as the "specialist in specials," — leads in production of special designs. Continental is also your supply source for special-purpose fasteners, such as HOLTITE NYLOK Self-locking Screws.

MORE "SPECIAL" PRODUCTION FACILITIES
With Continental's modern, precision controlled equipment, many special shaped screws formerly machined from bar stock can be produced faster, at lower cost — with higher tensile strength and excellent surface quality.

MEMBER
SCREW RESEARCH ASSOCIATION

CONTINENTAL

SCREW COMPANY, NEW BEDFORD, MASS.

HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING
THREAD FORMING •
SEMS • NYLOK

HY-PRO PHILLIPS
INSERT BITS AND HOLDERS

HY-PRO TOOL COMPANY. . . DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY

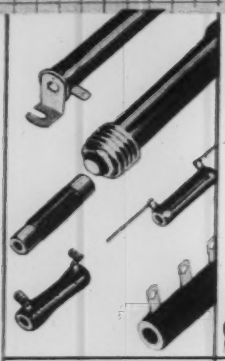
Circle 429 on Page 19

OHMITE® industry's most complete line of WIRE-WOUND RESISTORS

WRITE ON COMPANY LETTERHEAD FOR CATALOG 58

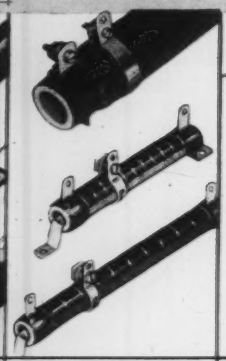
Ohmite has exactly the resistor you need

Ohmite offers the most complete line of high quality resistors on the market . . . fixed, adjustable, tapped, noninductive, and precision resistors in many sizes and types of terminals . . . in a wide range of wattages and resistances. All-welded construction. Ohmite application engineers will be pleased to help you in selecting the resistors for your job.



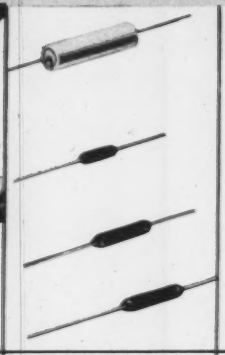
FIXED

Resistance wire is wound on a ceramic tube and protected by a vitreous-enamel coating. Many kinds of terminals available. May be single winding, tapped, or multisection. Watts, 3 to 1000; ohms, 0.1 to 1,700,000.



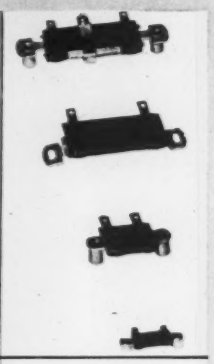
DIVIDOHM ADJUSTABLE

Vitreous-enameled resistors with the wire exposed in a strip along one side for contact with adjustable lugs. Most Ohmite resistors can be ordered adjustable. Watts, 10 to 1000; ohms, 1 to 100K.



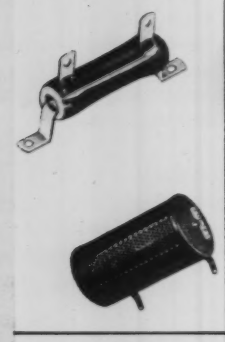
AXIAL LEAD

Small vitreous-enameled resistors with wire leads axially welded to caps on ends of the units. Also TUBEOHM ceramic jacketed style. Watts, vitreous 3 to 10; Tubeohm, 5 to 25; ohms, vitreous 1 to 50K; Tubeohm 1 to 25K.



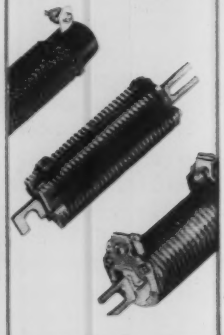
THIN

Resistance wire is wound on a core of flattened oval cross section and protected by vitreous enamel. Several sizes. Fixed, adjustable or tapped. Watts, 10 to 75; ohms, 0.1 to 100K.



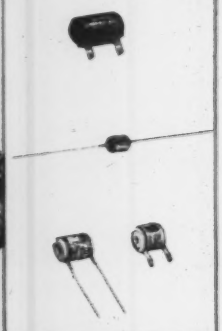
NONINDUCTIVE

Tubular vitreous-enameled resistors with special winding. Dummy antennas consist of assemblies of several resistors. Watts, 5 to 1000; ohms, 1 to 5000.



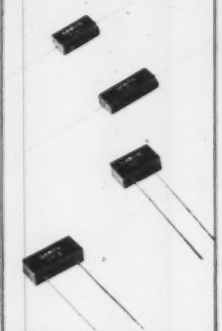
HIGH CURRENT

CORRIBS have exposed corrugated ribbon wound and enameled on a tubular core. POWR-RIBS have bare coil of edgewise wound ribbon or round wire.



PRECISION WIRE-WOUND

Pie-wound resistors, encapsulated, impregnated, or hermetically sealed in glass. Also standard resistors wound to close tolerance. Watts, ⅛ to 2; ohms, 0.1 to 5 megohms.



PRECISION METAL FILM

Consists of a unique metal film permanently bonded to a glass plate. The assembly is sealed in a high-temperature resistant plastic case. Watts, ¼ at 150°C to ½ at 105°C; ohms, 25 to 350K.

SPECIAL VARIETIES

Ohmite can provide toroids, flat strips, plaques, special-sized tubes, or tubes with mixed terminals, etc. Watt ratings and resistances are available as required.

RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

OHMITE® QUALITY Components

These Blaw-Knox steamchests show how (right) Trentweld tubes are inserted, (center) gas fusion welded to the tube sheet, and (left) welded and polished to well-rounded joints which leave no corners or crevices for bacteria or corrosion build-up.

high strength of TRENTWELD TUBING

reduces a steamchest's weight, increases its service life

Here's a case where the high strength of Trentweld® tubing reduced a steamchest's over-all weight while (1) increasing its service life, (2) improving heat transfer, (3) eliminating possible sanitation problems, and (4) reducing clean-up work.

These steamchests, made by Blaw-Knox Company for heating milk, frequently contain 3,000 feet of stainless steel tubing. Previously, Blaw-Knox expanded heavy-wall tubes into the tube sheet. Now, using welding techniques developed by Trent's Technical Service Group and Blaw-Knox welding supervisors, workers easily weld lighter gauge Trentweld tubes to the sheet and polish the joints. This eliminates any chance of bacteria growth during processing and of crevice corrosion during clean-up.

Trent's Technical Service Group can help you improve your product with Trentweld tubing, too. That's because Trent's exclusive welding process virtually eliminates any beads or undercuts, and because Trent cold works and anneals its tubing to make the weld as strong and corrosion resistant as the parent metal. The result? *Tubing that's as strong and uniform as tubing made by any other method.*

Mail coupon for catalog . . .

CONTOUR TRENTWELD TUBING is available in sizes ranging from ⅛" to 40" O.D. and grades including Hastelloy,* Zirconium, Zircaloy, Titanium, 19-9-DL – for applications in every industry.

*Trademark of Haynes Stellite Co.

CONTOUR TRENTWELD

TRENT TUBE COMPANY
Subsidiary of Crucible Steel Company of America

General Offices: East Troy, Wisconsin*

Gentlemen:
Please send me the *free* 48-page Trent tubing handbook.

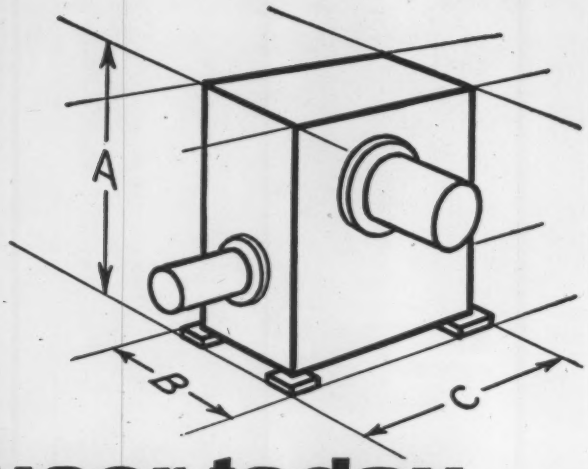
*Name*_____
*Title*_____
*Company*_____
*City*_____ *Zone*____ *State*_____

***Or write: Trent Tube Company, Fullerton, Calif.**

Circle 431 on Page 19

(Advertisement)

Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

Circle 432 on Page 19

Circle 433 on Page 19→

Years ahead G-E Form G motors designed to...

Since these motors were first introduced they have been the key to new design ideas . . . ideas to improve products, cut costs, and simplify assembly and production procedures. They can do the same for you!

MATCH YOUR PRODUCT DESIGN IDEAS

DESIGN IMPROVEMENT

With General Electric Form G Motors

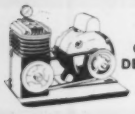
Decora Manufacturing Company

G-E MOTOR CUT PRODUCT WEIGHT 33%

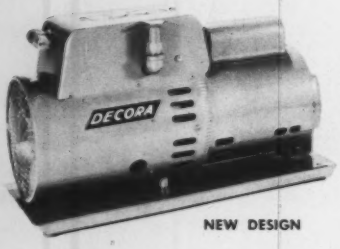
Decora Manufacturing Company set out to design a new portable compressor . . . lighter and more compact . . . intended to deliver a good volume of high pressure air.

The General Electric Form G ¾ hp motor was a natural—it required 40% less space, weighed only half as much as the motor they were using, and made possible the new model compressor.

Today, weight of the new compressor is down 30 pounds. Shipping costs are down an average of $1.50 per unit. The sleek modern lines of Decora's compressor make it look better and sell faster.

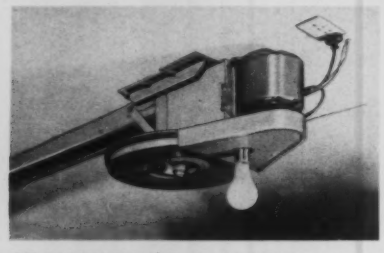


OLD DESIGN



NEW DESIGN

Barber-Colman, OVERdoors and Operators Division



STANDARD G-E MOTOR FEATURES CUT COST 12%

General Electric's Form G motor helped Barber-Colman realize a 12% savings in manufacturing costs. And standard, no-extra-cost features did it . . . G.E.'s all-angle sleeve bearing design and the removable cradle base.

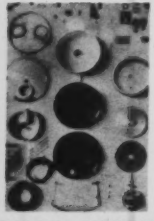
Tests proved that the G-E motor could be mounted shaft-down without sacrificing lubricating or performance qualities, thanks to G.E.'s all-angle sleeve bearing. This saved Barber-Colman the *extra* expense of ball-bearing motors for this application.

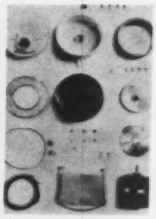
An extra benefit: In previous Barcol Automatic Door Operators, two heavy expensive mounting brackets to hold the motor had to be manufactured and assembled. In today's design, the G-E motor's removable base is spot-welded directly to the operator frame, cutting over-all product weight and saving on assembly time.

In all, these advantages meant a *definite product improvement at a 12% cost reduction.*

Sweden Freezer Company

BEFORE—57 Parts **NOW—28 Parts**





FEWER PARTS REDUCE ASSEMBLY TIME 63%

The photographs above help to show the *design simplification* which the G-E motor made possible in the new Sweden Speed Juicer. Results:

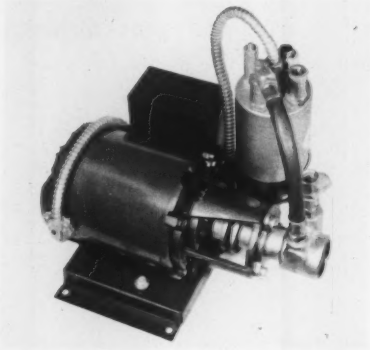
Reduced number of parts 50%, from 57 to 28 pieces.

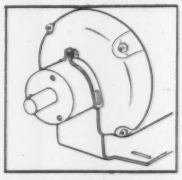
Nearly doubled production with a minimum increase in payroll.

Cut installation time 63% over the previous method.

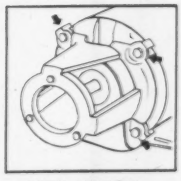
Made product more compact, more attractive, more dependable.

Temprite Products Corp.





OLD DESIGN



NEW DESIGN

ELIMINATED COSTLY MACHINING OPERATION

A standard General Electric fhp motor enabled Temprite Products to cut manufacturing costs and simplify the design of their "Bantam 100" carbonator pump.

Temprite was using another manufacturer's special motor with an integral pump mounting. The close tolerances found on *all* standard Form G motors made it possible for them to eliminate the costly special motors.

Reason: Close tolerances let them switch to an open, lightweight bracket designed by a leading pump manufacturer to fit G.E.'s standard endshield.

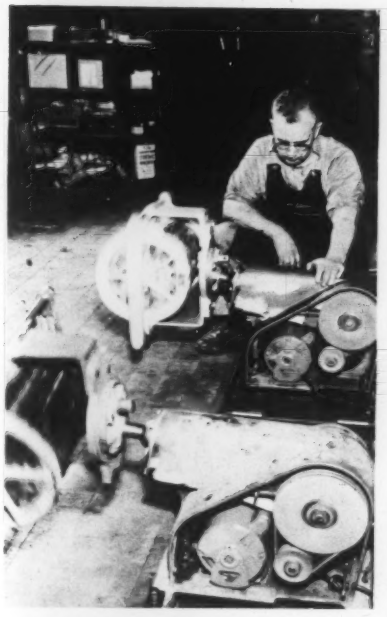
No special machining was required because every G-E fhp motor is designed and manufactured to these rigid specifications:

- Each boss face (shown in "new design" above) is cast to 0.01 inch wabble relative to the bearing bore.
- Outside diameter of the pulley endshield is held to 0.004 in. tolerance and 0.004/.005 in. on eccentricity.

Results: Elimination of added cost of special motors, a weight reduction of *over 50%,* and a more compact, lower cost pump.

IDEAS

Red Devil Tools



650 SHAKES PER MINUTE

General Electric Form G motors are built to take it . . . and here's proof! This Red Devil paint conditioner operates at the rate of 650 shakes per minute, a severe test for any motor.

Red Devil engineers looked long and hard for the right motor. They required small size. Bearings had to be extra rugged. Insulation had to be able to shrug off vibration. Windings had to be bonded to stay. A breakdown in any of these components would cause motor failure and reflect on the quality of their machine.

General Electric's *standard* Form G motor matched the extra-high quality Red Devil demanded. Engineers from G.E.'s General Purpose Motor Department helped in applying the right motor, made many test runs, and offered free engineering assistance both in the factory and at the Red Devil plant. The result: a high quality, truly *dependable* machine.

An extra benefit: Red Devil's customers, like most machine buyers, prefer General Electric motors . . . and there's a General Electric small motor service station in every part of the country ready to give fast, emergency service.

A full line of General Electric years ahead fhp motors is available in the ratings you need

General Electric offers you prompt delivery on more than 850 basic models. You can choose the right motor for your product without buying costly "specials."

GENERAL ELECTRIC'S ENGINEERS WILL HELP YOU WITH *YOUR* PRODUCT REDESIGN PROGRAM

General Electric's sales engineers are ready to help you lower costs, increase the power of your product, or improve its design. Years of experience have taught them many "tricks of the trade" which can help you meet your product requirements at lower cost.

Just call your General Electric Apparatus Sales Office. An experienced sales engineer will call as soon as possible. And, if your problem is especially tough, factory application engineers will be called in, too!

Why not start a redesign program of your product's drive system today? Call now to find out how you can improve your product . . . at a savings! General Electric Company, Section 702-68, Schenectady 5, N. Y.

OPERATION upturn — Buy now for extra values — GENERAL ELECTRIC

Progress Is Our Most Important Product

GENERAL ELECTRIC

the profit you left behind

There it lays in the dirt. Your machines and equipment ground off in the grit, pounded off in the rock and ore. You can almost see the wear that shut down your machines too soon . . . idled your men too long . . . bled your profits too much.

Is there *one* material, *one* metal that can stop this excess wear waste?

One? It takes many alloys, engineered alloys (some you may never have heard of). It takes a list of Amsco® Alloys to span the entire range of wear applications.

Amsco Alloys that can work a full shift where severe abrasion knocked out toughest metals in three hours. Amsco Alloys that can belt rock and ore all day, and work tomorrow, too. Amsco Alloys that can work any abrasion-impact combinations you face and still resist the wear, stop the waste . . . save the profit!

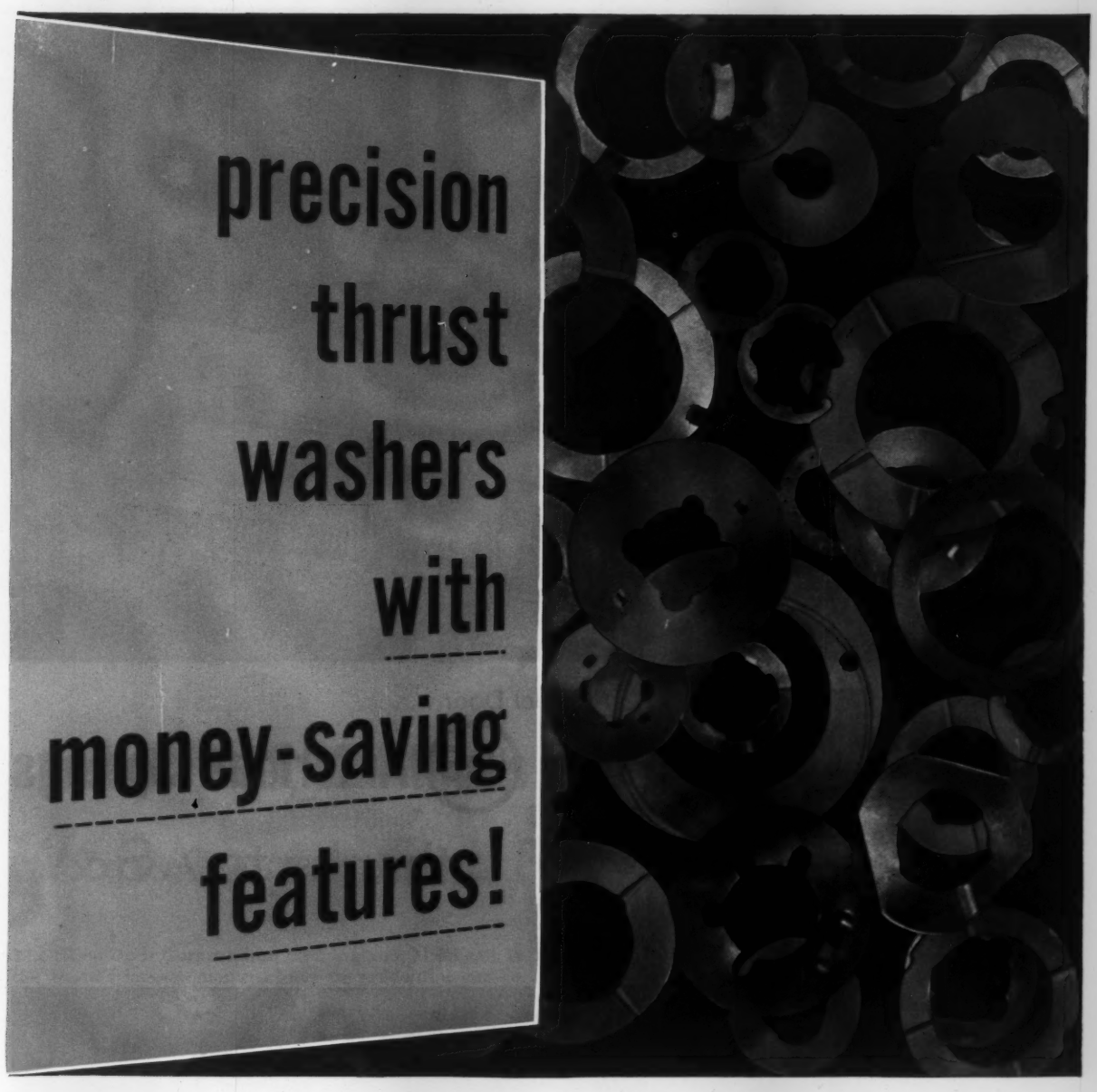
When you need the *best* alloy for the job, you'll find it *first* among the Amsco Alloys . . . engineered by America's largest producer of cast manganese steel and specialists in wear-resistant metals.

AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division · Chicago Heights, Illinois

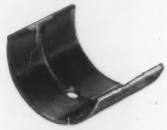
precision thrust washers with money-saving features!



Copper-alloy bearing surface on one or *both* faces of cold rolled steel. Slots, nibs, lugs to your design. Coined oil grooves—*no* costly machining. Write for the money-saving facts:

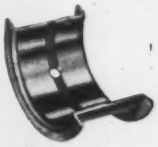
FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN



Copper-Alloy Lined

Spacer Tubes



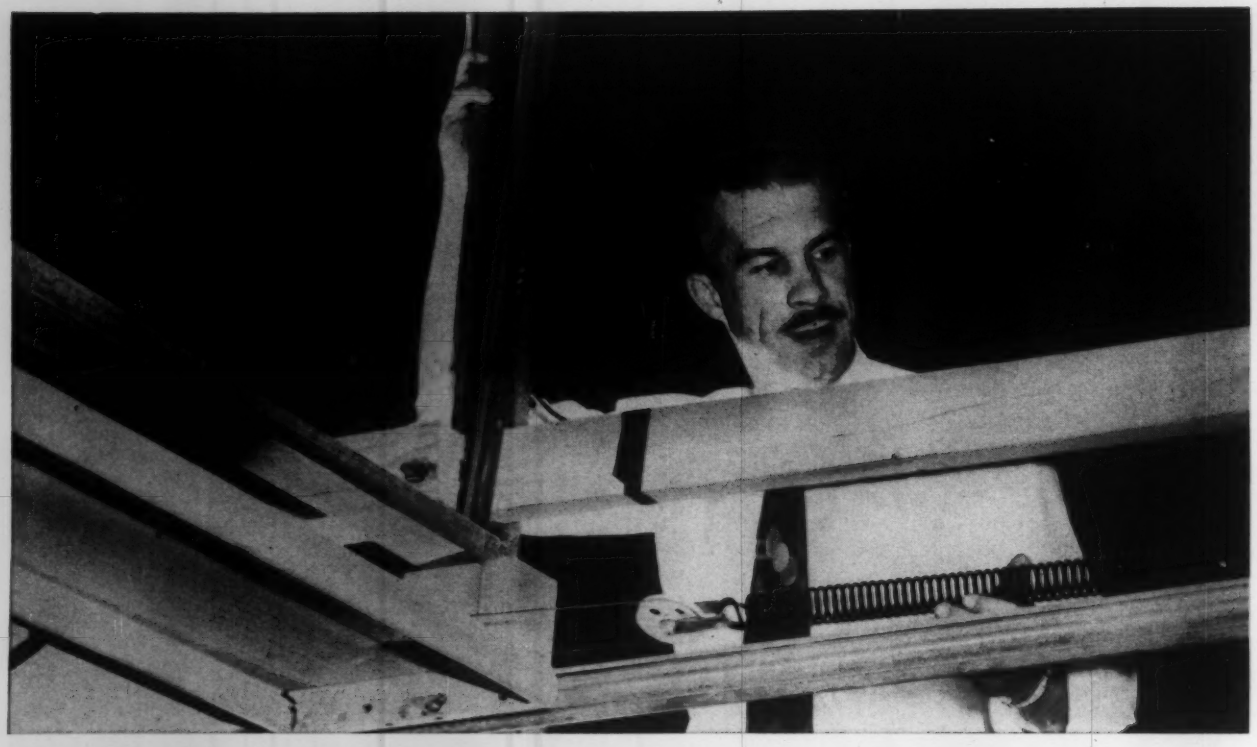
Aluminum or Babbitt Lined

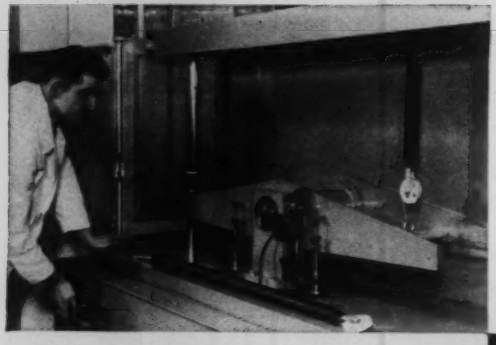
Plain & Bimetal Split Bushings

FEDERAL Mogul SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 435 on Page 19



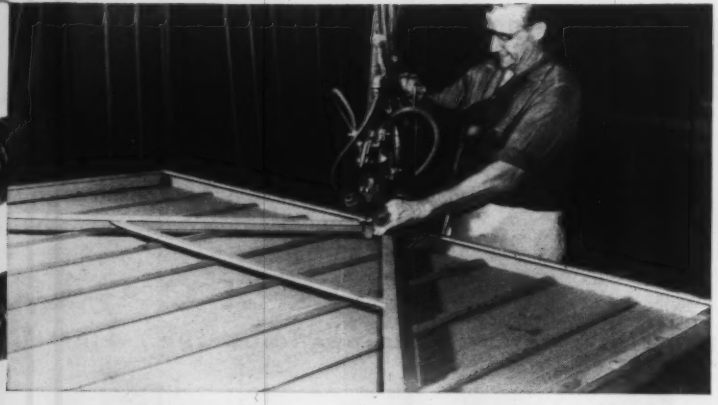


At Steel Door . . .

USS American Springs

thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, General Offices: Rockefeller Building, Cleveland 13, Ohio.*

USS and American are trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

Miniature Directional Signal. A foraging bee brings home one drop of nectar. His fellow workers sniff it like bloodhounds, and from the scent know just where to go for more. This tiny droplet is nature's miracle for keeping bees on the beam.

Miniature Selector Switch. Missiles stay on course when controlled by complex selector switch. Two MPB bearings on its shaft make frictional torque practically negligible, keep total weight down to .42 ounce. It's a man-miracle in miniaturization.

Man With Miracles. This is Hank Eckert, one of MPB's Sales Engineers. He helped the selector switch people find exactly the right type of MPB radial retainer bearing to hold friction to a minimum, give dependable service and assure operating precision.

Designers' dream world Miracles in Miniaturization

BEARING ACTUAL SIZE

New Miracles. Today's industrial scientists are pioneering a whole new world of man-made miniaturization. With MPB miniature bearings and experience it is a wide, wide world on a tiny scale. For in miniaturization, bearings are one of the most critical considerations.

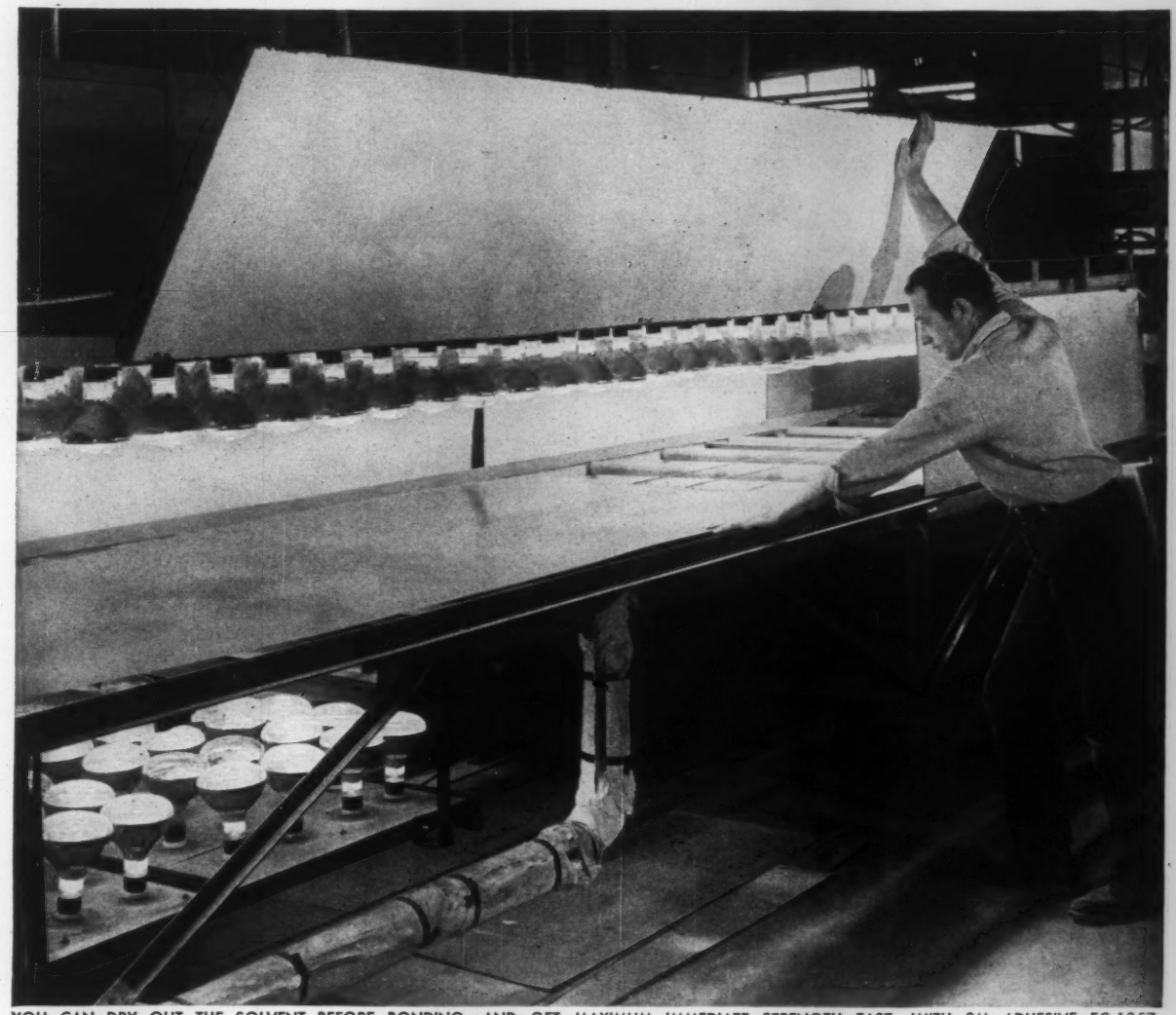
MPB makes miniature bearings 3/8" O.D. *down* (specials on request). In stock—over 500 types and sizes. Consult MPB when you are embarking on a miniaturization problem and/or write for new MPB catalog. **Miniature Precision Bearings, Inc.,** 108 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

Circle 437 on Page 19

Speed high-strength sandwich bonding by predrying 3M adhesive EC-1357



YOU CAN DRY OUT THE SOLVENT BEFORE BONDING—AND GET MAXIMUM IMMEDIATE STRENGTH FAST—WITH 3M ADHESIVE EC-1357.

Here's new speed in making light, rugged sandwich panels for non-load-bearing uses!

It's EC-1357. This specially formulated, fast adhesive from the laboratories of 3M gives you high bond strength *immediately!* With infrared ovens, you can dry the solvent out of EC-1357 before bonding. Heat absorption is fast, due to EC-1357's dark color. You eliminate unnecessary drying and storage time. You need no clamps or heated presses, just cold press or nip roller. What's more, this cold bond continues to cure at room temperatures—gains added strength with age.

On metal or paper honeycomb cores, EC-1357 builds up a fillet for bigger bonding area and strength. Use EC-1357 with glass foam cores, too.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research, contact your 3M Field Engineer or write on your company letterhead for information and free literature to: 3M, Dept. C-8, 417 Piquette Ave., Detroit 2, Mich.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY • ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.

Circle 438 on Page 19

New Garlock VITON A† Rubber Parts Give Maximum Resistance to Solvents and Heat

Unharmed by exotic new fuels, solvents, acids, bases

Garlock VITON A rubber parts are more resistant to harmful liquids than any other rubber known. Following is a partial list of liquids you can use in contact with VITON A. It has extremely low swell in solvents:

OS 45 hydraulic and turbo oil	Cellulube
ASTM #3 oil	Benzene
ASTM reference fuel B	Carbon tetrachloride
Kerosene	Carbon disulfide
JP-4 fuel	Naphtha
Ethylene Glycol	Aniline
	Trichlorethlene

Still flexible at 600° F. In addition to excellent resistance to deterioration by liquids VITON A rubber parts perform excellently in heat up to 600° F. for limited periods of time without significant loss of elasticity. After oven aging for 1 week at 500° F. VITON A shows only the slightest change in duro, tensile strength, and elongation characteristics.

Good compression set. Using the ASTM-D-395 method B for 70 hrs. at 350° F. it shows as low as 25% set.

Hundreds of Applications. Garlock VITON A molded and extruded parts are for use on aircraft, missiles, automotive and other mechanical equipment where you need a rubber which gives maximum resistance to deterioration by liquids and heat.

Also available as sealing elements in KLOZURE* Oil Seals, flexible members in MECHANIPAK* Mechanical Seals, "O" Rings, cups, CHEVRON* packing. VITON A products are another part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line. See your local Garlock representative, or write for further information.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

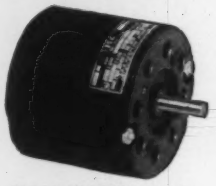
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

*Garlock Trademark †Du Pont Trademark

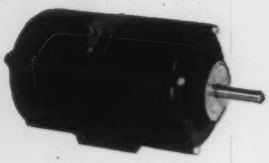
Circle 439 on Page 19

EVERY HOUR

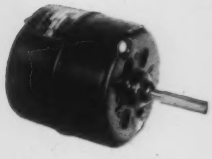
2 new applications are filled by HOWARD Fractional Horsepower Motors



Model 2800 Illustrated
Shaded Pole Motors
1/2000 to ⅛ H.P.



Model 2900 Illustrated
Induction Motors
1/1400 to ¼ H.P.



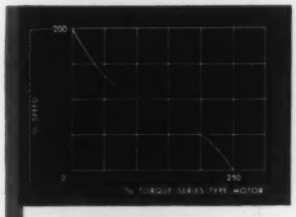
Model 11A Illustrated
Universal and D.C. Motors
1/100 to ½ H.P.

MORE THAN 100,000 FILLED SPECS ON FILE

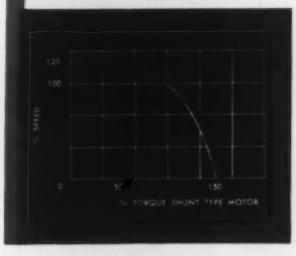
Through the years, designers and purchasing agents have learned that they can *depend* on Howard to *quickly* and *inexpensively* produce a motor to *any* specifications. With over 100,000 specs on file, chances are Howard engineers have worked on applications similar to yours—and can easily meet your mechanical, electrical and cost requirements. To aid you in selecting the right motor for a particular job, general characteristics of the basic Howard motor types are listed below. Whatever your needs, if you're in the market for power—check with Howard first.

CHARACTERISTICS AND TYPICAL SPEED TORQUE CURVES OF BASIC HOWARD FRACTIONAL HORSEPOWER MOTOR TYPES

UNIVERSAL MOTORS



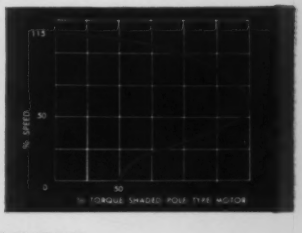
Series Type
Power: DC and AC 25 to 75 cycles.
1. High No Load Speed.
2. Full Load Speed (Optimum Performance) at approximately 50% no load.
3. Starting Torque high, 200 to 300% full load torque.
4. Variable speed, speed decreases with increasing loads.



Shunt Type **Power:** DC only.
1. No load and Full load speed are adjustable by winding or by armature and/or field voltage control. Approximately a 2:1 speed range can be obtained by field control, and 10:1 by armature control.
2. Fairly constant Full load speed.
3. Regulation varies from 10% to 30% depending upon duty and power requirements.
4. Starting torque, approximately 150 to 200% of Full Load.

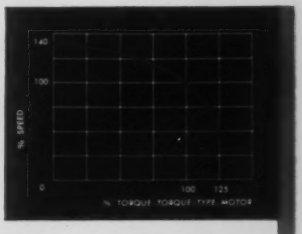
SHADED POLE MOTORS

Power: AC 50 to 60 cycles.
1. No load speed is determined by the number of poles with a No load slip of 3 to 5%.
2. Fairly constant Full Load Speed, with a full load slip of 10 to 20%.
3. Breakdown torque approximately 150% of full load.
4. Starting torque low, 50 to 75% of Full load.

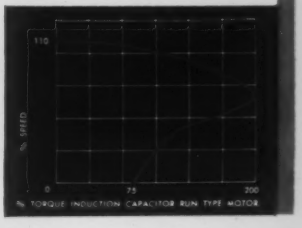


INDUCTION MOTORS

Torque Type
Power: AC 50 to 60 cycles.
1. No load speed is determined by number of poles, with a No load slip of approximately 5%.
2. Full load speed decreases with an increasing load. Designed to operate at approximately 30% full load slip.
3. No breakdown torque.
4. Startina torque high approximately 125% full load.



Capacitor Run Type
Power: AC 50 to 60 cycle.
1. No Load speed is determined by the number of poles, with a No load slip of 2 to 4%.
2. Constant full load speed, with a full load slip of approximately 10%.



Hysteresis Synchronous type
Power: AC 50 to 60 cycles.
1. Constant synchronized speed, determined by number of poles.
2. Starting torque equal to full load torque.
3. Quiet operation.

Reluctance Synchronous type motor
Power: AC 50 to 60 cycles.
1. Runs at a synchronized speed, determined by the number of poles.
2. Starting torque low, 50 to 75% of full load.

POWERED BY **HOWARD**

Other Howard motors: UNIVERSAL & D.C. 1/200 to 1 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

HOWARD INDUSTRIES, INC., 1735 State St., Racine, Wis., Telephone ME 2-2731, Teletype: RAC344

Sales Offices
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942 S. La Brea Ave., Los Angeles 36, WE 8-2444
Room 4822, Empire State Bldg., New York 1, LO 4-7992
300 Broadway, Camden, New Jersey, WO 49733
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Representatives in Principal Cities Consult Your Classified Phone Book

Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS · LS LOYD SCRUGGS COMPANY

Enlarged 75 times, screw-machined aluminum bushing shows finer precision than the grooves of the L-P record on which it rests.

What the designer conceives . . . aluminum achieves!

0.040-INCH DIAMETER ALUMINUM BUSHING TO HOLD L-P RECORD PLAYER NEEDLE

Designers: Fidelitone, Inc.; Jensen Industries
Screw Machine Operator: Walter Precision Company

The sensitive diamond or sapphire needle used in modern L-P record players must be held by a precision bushing that is soft, but at the same time very strong.

SOFT—to permit the needle to be inserted by gentle pressure.

STRONG—to hold the needle firmly in precise alignment through years of use. In addition, the holding piece must be non-magnetic and light weight.

To best fit these conditions of the bushing design, aluminum was selected. But because the smallest readily-available aluminum rod was ⅛-inch size, they still had the problem of grinding down to a center size of 0.045 before manufacturing the bushing.

Their solution? . . . call Kaiser Aluminum screw machine design and operator specialists. Kaiser Aluminum, besides drawing the rod to 0.045, also *straightened* the coiled aluminum into 10-foot rods.

This material was held to a plus or minus .0005 inch, making it possible to maintain concentricity and finish the part to these dimensions: Diameter 0.040; Overall Length 0.050 to 0.055; Inside Hole Diameters 0.0145 and 0.0165. The smallest O.D. is 0.027 to 0.028, making a wall thickness of only 0.0065.

The manufacturer now gets four times as many parts from the same amount of metal—about 36,000 parts per pound—at half the former cost!

Kaiser Aluminum specialists are immediately available to offer design and production assistance for *any* screw machine problem that you may have. Call the Kaiser Aluminum sales office or distributor listed in your telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, Calif.

FOR THE COMPETITIVE EDGE, GO ALUMINUM

KAISER ALUMINUM

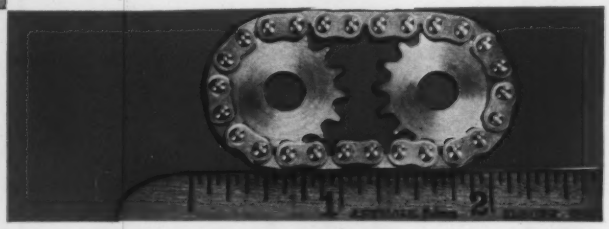
SEE 'MAVERICK' • SUNDAY EVENINGS, ABC-TV NETWORK • CONSULT YOUR LOCAL TV LISTING

Here's full-scale efficiency in a fractional hp drive

CHAIN AS SMALL AS THIS

SPROCKETS AS SMALL AS THIS

A COMPLETE DRIVE AS SMALL AS THIS



LINK-BELT 3/16-in. pitch Silent Chain is smooth, quiet, positive at high or low speeds

Here's the ideal drive for limited-space applications. Despite its pitch of only 3/16 inches . . . weight as little as .07 pounds per foot — this durable Link-Belt drive is better than 98% efficient. In fact, it often replaces expensive, precision-cut gear trains.

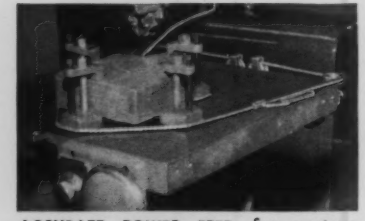
It's available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. Book 2510 explains outstanding features, including tooth and link form which eliminates chordal disturbance. Write for your copy to LINK-BELT COMPANY, Dept. 316, Prudential Plaza, Chicago 1, Illinois.

LINK-BELT

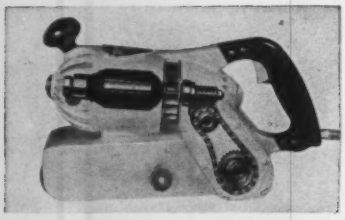
SILVERSTREAK SILENT CHAIN DRIVES

Link-Belt 3/16-in. pitch silent chain is installed as original equipment on

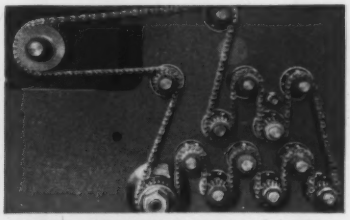
aircraft	portable planers
bread slicers	portable sanders
button making machines	radar equipment
cameras	recording machines
cigar making machines	rubber slicing machines
looms	sealing machines
meters	sewing machines
motion picture machines	timing devices
oil burners	typewriters
packaging machinery	vending machines



ACCURATE POWER FEED for contour shaping machine is assured by Link-Belt 3/16-in. Silverstreak silent chain.



POSITIVE POWER TRANSMISSION by Link-Belt 3/16-in. silent chain drive aids portable belt sander efficiency.



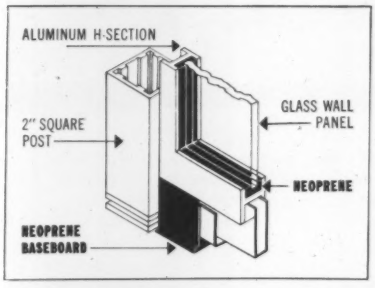
PERFECT SYNCHRONIZATION of intricate 14-wheel drive is maintained by Link-Belt 3/16-in. Duplex silent chain.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,251

Circle 442 on Page 19

U-shaped gasket of Du Pont neoprene remains resilient under compression, resists deformation, and retains its sealing properties despite frequent movement of the panels.

Movable panels cushioned with gaskets of Du Pont neoprene



Section of office partition. Aluminum H-sections, keyed into 2 in. square posts, support the panes. Neoprene gasket seals and cushions the glass. Baseboard is also neoprene.

Two linear miles of office partitions were installed in the new Connecticut General Life Insurance building in Hartford, Connecticut. In designing the movable walls, architects Skidmore, Owings, and Merrill required a resilient cushion for the panes. They chose extruded gaskets of Du Pont neoprene synthetic rubber.

Neoprene is a vulcanized rubber, not a thermoplastic. It does not "cold flow" under pressure, nor relax over the years and lose its grip on the edge of the glass. Neoprene is chemically stable, and is highly resistant to the slow deteriorating process of natural aging. It is outstanding among elastomers for its ability to retain its properties for long durations of time. Neoprene will not crack, harden, or lose its strength and extensibility.

A combination of durable properties makes neoprene an excellent choice for parts and products that must withstand severe conditions. Neoprene is resistant to oil and grease, most chemicals, abrasion and cutting. It performs well over a wide temperature range and will not support combustion. Samples of Du Pont neoprene have withstood 23 years' exposure to sunlight and weather.

For more information on the properties and design possibilities of neoprene and HYPALON®, a new Du Pont synthetic rubber, clip the coupon below.

ELASTOMERS IN ACTION HYPALON® • NEOPRENE

DU PONT
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Better Things for Better Living
. . . through Chemistry

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of the properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on the uses of Du Pont elastomers in industry).

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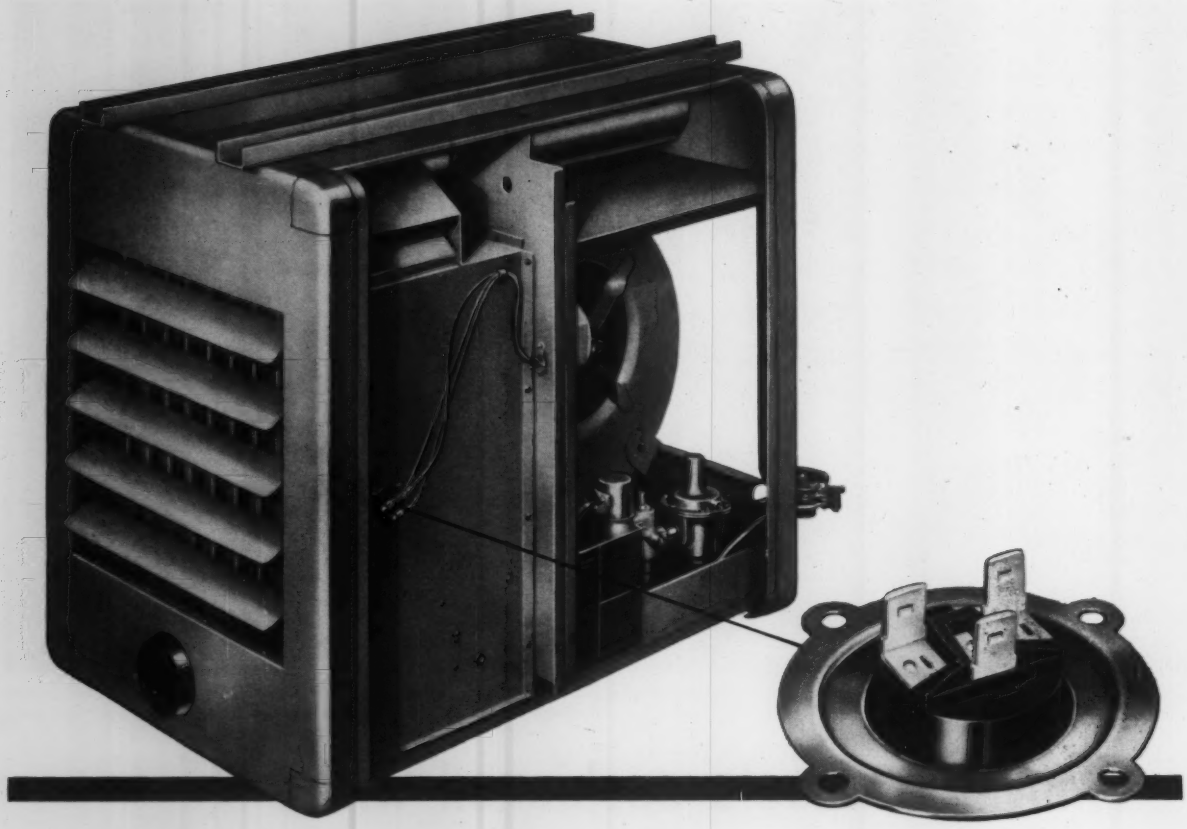
Elastomer Chemicals Dept. MD-8
Wilmington 98, Delaware

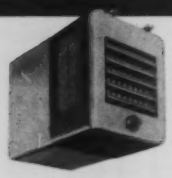
Name _____
Firm _____
Address _____
City _____ State _____

Circle 443 on Page 19



Modine chooses **KLIXON** Snap-Acting Thermostat

for Low Cost • Inherent Safety • Ease of Application



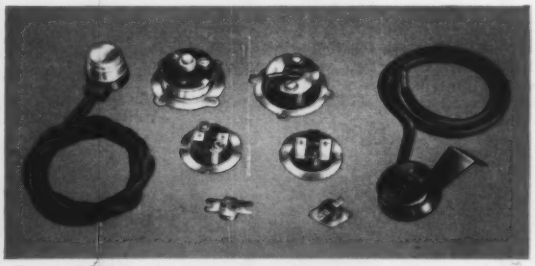
"The KLIXON *fixed-temperature, snap-acting thermostat was selected for our new Modine blower type gas fired unit heater on the basis of low cost, inherent safety and ease of application to our unit."*

That's how the Modine Manufacturing Company, one of the nation's foremost makers of gas heating equipment, feels about KLIXON Thermostats. And, Modine goes on to say:

"As an important component in the control system, we are sure that the KLIXON *Thermostat helps us provide 100% safety in our unit."*

Today hundreds of leading original equipment manufacturers specify and use KLIXON Controls. These controls are available in both sealed and open construction in a wide variety of types and sizes. Fixed temperature settings are custom calibrated at the factory to meet the customer's requirements.

Competent Spencer Division engineers at the factory and in the field will gladly help you make test applications of KLIXON Controls. Send for free literature on the KLIXON line now and get acquainted with the application possibilities on your equipment.



Typical KLIXON Fixed Temperature Controls for many types of home appliances.

METALS & CONTROLS CORPORATION

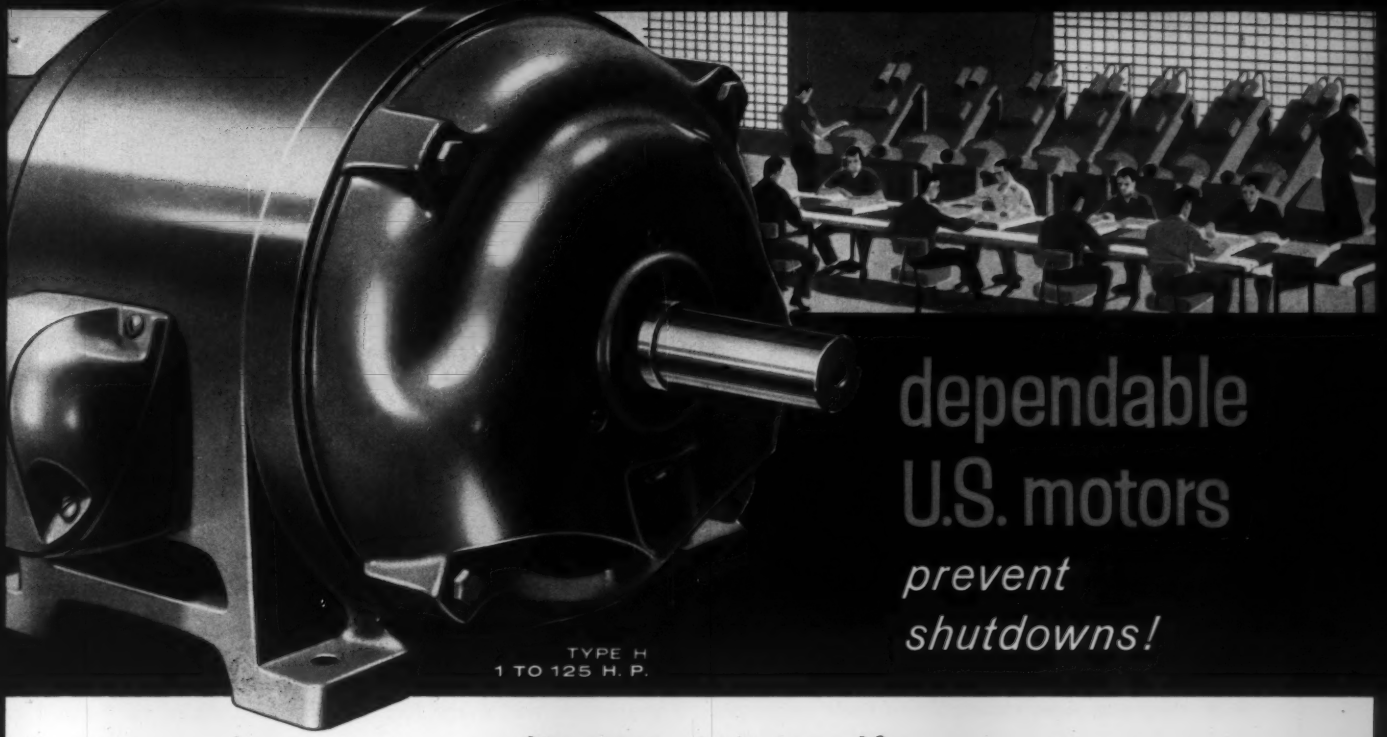
Spencer Division

3208 Forest Street, Attleboro, Mass.

KLIXON®

Circle 444 on Page 19

production shutdowns **cost more than motors!**



dependable U.S. motors *prevent shutdowns!*

...it pays to specify

U. S. Uniclosed Motors

Because production shutdowns *cost far more than motors,* real economy lies in buying motors of *quality* you can depend on! U.S. UNICLOSED is the motor choice for normal production needs. U.S. UNICLOSED MOTORS give you the quality and dependability that are built into every U.S. motor—plus protection *far* superior to ordinary dripproof motors. Only U.S. protects all windings with nature's non-organic, non-carbonizing insulation—asbestos! This prevents costly burn-outs. Unlike ordinary makes, U.S. motors have shock-resistant, corrosion-resistant cast iron frames that are *normalized*—heat-seasoned to prevent warp! To protect bearings, U.S. LUBRIFLUSH transverse lubrication purges old grease. This minimizes lubrication and maintenance requirements. These and many other factors add up to U.S. *quality*—the kind you can depend upon to keep production lines running! U.S. UNICLOSED 3-phase AC motors are available in RATINGS ¼ to 250 H.P. It pays to specify: "U.S. MOTORS."

U.S. ELECTRICAL MOTORS INC.

BOX 2058, LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

FREE COLOR-ILLUSTRATED BROCHURE
For detailed data on Uniclosed Motors, write for Uniclosed Bulletin No. F-1856

Circle 445 on Page 19

Formability—In days of old, when knights were bold, they also were smart. When their very lives depended on a tool or a weapon, they made sure it was made from steel. It could be a great claymore, hefty enough to behead a horse; a bright suit of armor that would turn the Saracen's arrow; or an ornamental castle gate, strongly made to frustrate the assassin.

They wanted steel because it was strong. They could *use* it because it was formable. Truly, there is no economical metal in all the world that can approach steel's combination of strength and formability.

With the near-magic of heat treating, you can soften steel and form it, then harden it to make it strong, then temper it to make it tough. Or form it cold. Use bending, flanging, deep drawing, spinning, cold heading, die drawing, rolling, wiper forming, draw rolling, stretch forming or bumping. In fact, it's hard to imagine any forming operation that cannot be performed on steel.

Fortunately, there are hundreds of different kinds of steel; and they all act differently in the fabricating shop. Everything you do to steel alters its *forming* properties, and every forming operation alters its physical properties.

The aim of the product designer is to find a steel that can be properly formed, that has the right strength, toughness, corrosion resistance, weldability or other characteristics required . . . at the most favorable cost. If you have a design problem and the comptroller is looking over your shoulder, take hope from this idea: there is one "best" steel for any design application. You can be sure of finding it among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless Steels.

If you need help in making your selection, ask a company that has produced well over a billion tons of steel, and has spent hundreds of millions of dollars to learn more about this most versatile of man's metals. Of course that means United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

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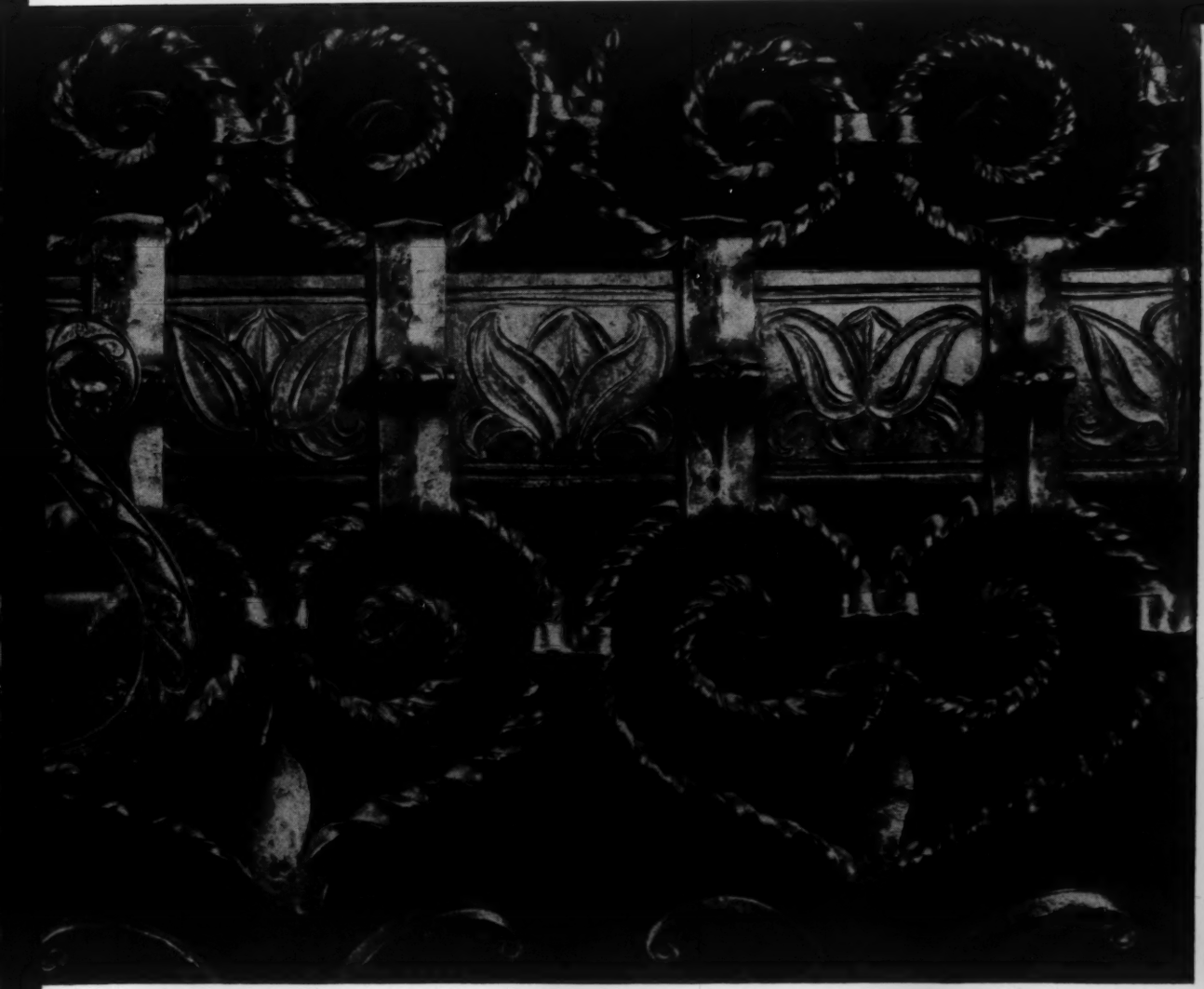


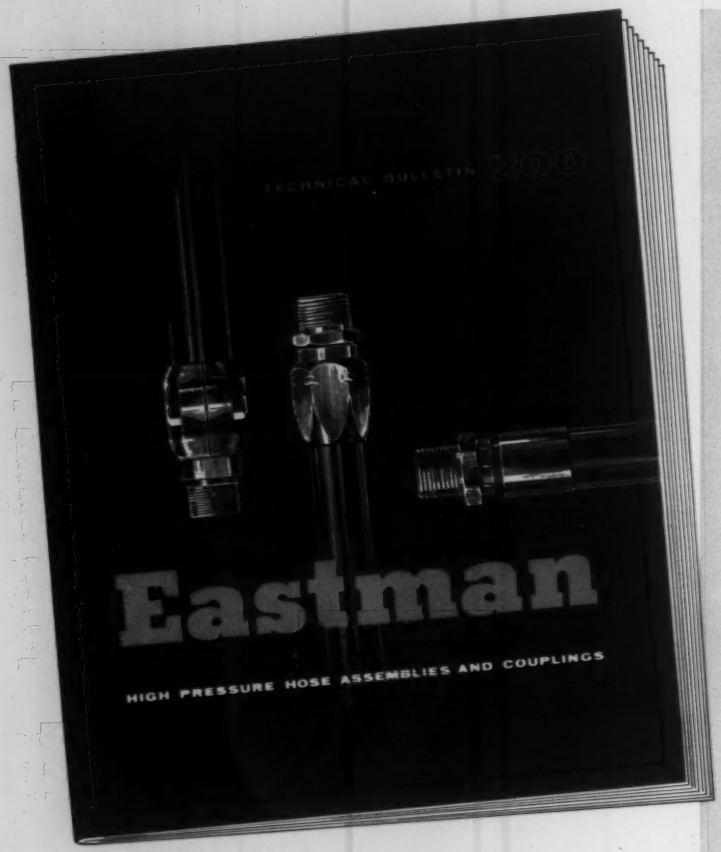
STEELS FOR OPTION

Lower Left—Problem: Build a power shovel dipper stick with greater strength and shock resistance. Solution: Bucyrus-Erie Company designed a tubular stick made from USS "T-1" Constructional Alloy Steel. Payoff: The "T-1" Steel plates were easily cold-formed into a tube and butt welded. The tubular design and stronger steel assured great strength and shock resistance, and easy fabrication.

Lower Middle—Problem: Produce strong, heat resistant, corrosion resistant jet engine rings—*economically*. Solution: Alloy Manufacturing Company carefully selected a grade of USS Stainless Steel. Payoff: The rings resist heat and corrosion and they are economically roll-formed because the Stainless Steel is formed on "carbon steel rated" equipment.

Lower Right—Problem: Design a pressure tank that is just as strong but lighter than conventional carbon steel tanks. Solution: Manufacturer selected USS MAN-TEN High Strength Steel. Payoff: MAN-TEN'S greater strength (50% higher yield point than carbon steel) permitted design of a thinner-walled tank that is 24% lighter. And because MAN-TEN is highly formable, the tank is economically produced by cold press forming of circular blanks into seamless shells, 29″ in diameter and 24″ deep.

USS, "T-1" and Man-Ten are registered trademarks



CONVENIENTLY ARRANGED TO HELP YOU MEET THE INCREASING DEMAND FOR HIGHER PRESSURES

Here's an entirely new service concept in catalog arrangement. It is designed to assist Engineers and Purchasing Agents in specifying Multi-Braid Hydraulic Hose and Tube Assemblies to meet the demand for increasing pressure requirements. With pressure as a primary consideration—the right assembly can be selected for the specific equipment on which it is to be used.

Nine major sections are devoted to assemblies suited to all types of high pressure hydraulic applications—complete with tables and specifications, including easy to read dimensional cross section drawings.

Include this new catalog in your files to make it easier to specify the proper assemblies.

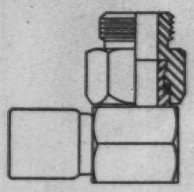
Write for Your Copy Today!

Eastman *first in the field* **MANUFACTURING COMPANY**
Dept. MD-8, MANITOWOC, WISCONSIN

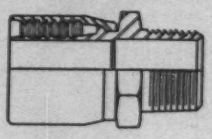
SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

AN INSIDE LOOK AT A *NEW BOOK*

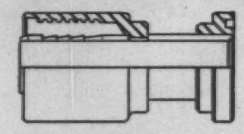
Eastman's new Technical Bulletin offers a new standard in simplified arrangement—for your convenience in specifying—according to your pressure requirements.



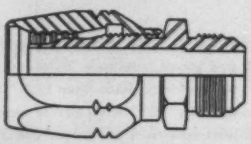
Swivel "O" Ring Male Couplings are available in 45° and 90° angles. Specifications on Page 13.



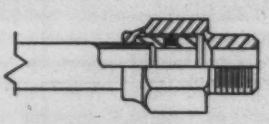
Permanently Attached Couplings for 2-wire braid hose. Specifications and Details on Page 10.



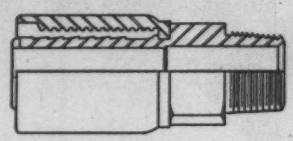
Permanently Attached Flange Head Couplings and Inserts from 0° to 90°. See complete list on Page 21.



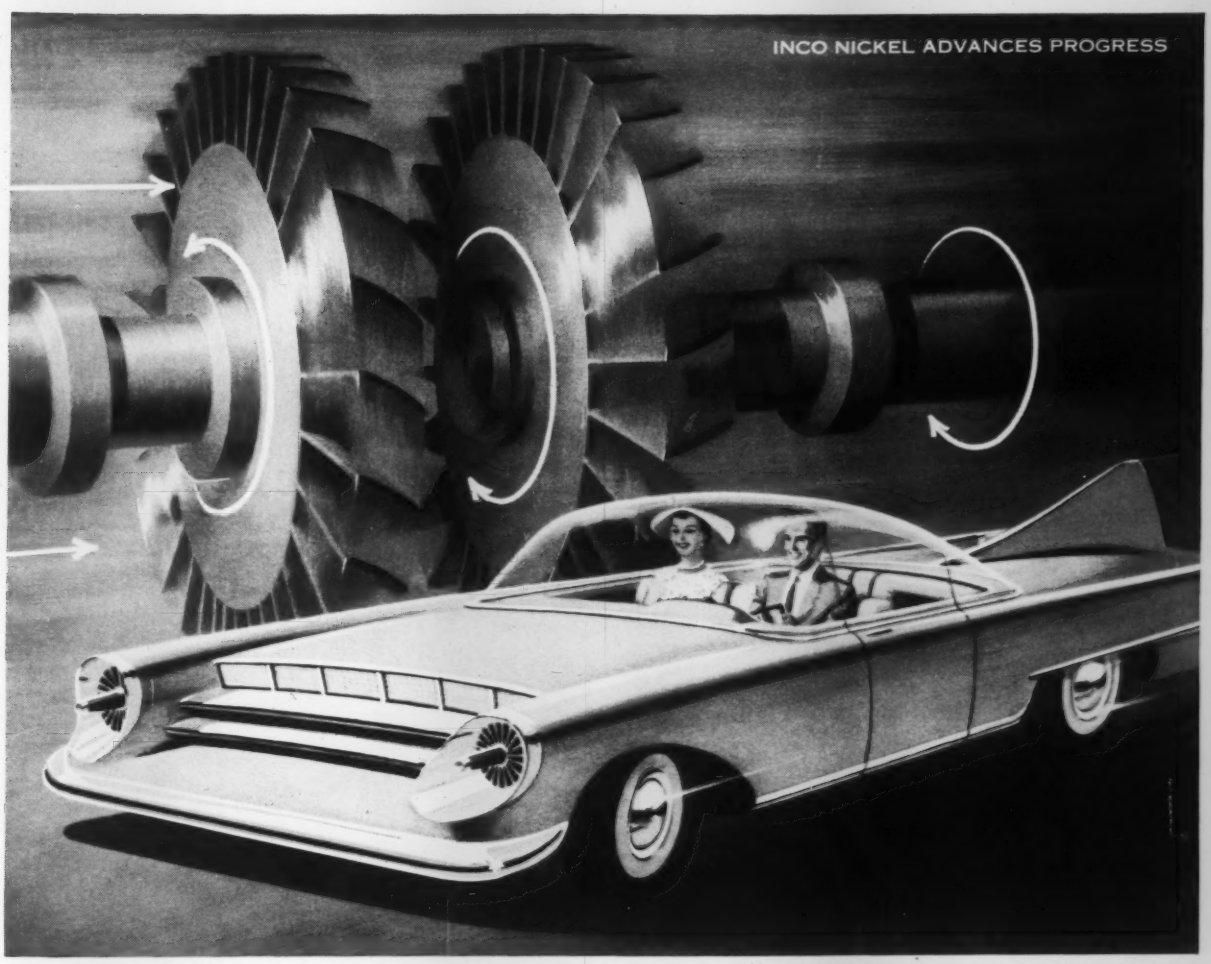
2-Piece Reusable Couplings for all high pressure hose. Used for pressures up to 5000 lbs. See Page 25.



Swivel Male Tube Nut "O" Ring Assembly used on formed tubing—described on Page 30.



Permanently Attached Couplings for **Extreme** High Pressures up to 7000 lbs. working pressure, Page 12.



This "windmill" or turbine, spun by hot gas, powers the turbocar. For such a hot spot, designers depend on Nickel to help them solve heat-resistance problems.

How Inco Nickel is helping develop your new gas turbine car of tomorrow

It will be power-packed: the gas turbine engine in your dream car of the future. In tomorrow's trucks and buses, too.

Only one spark plug— runs on kerosene

This new, power-packed engine is much lighter, much smaller than yours. It has far fewer parts. No pistons. No water system. Only one spark plug. And it runs on lower-grade fuels like kerosene.

Not yet in production!

Before this dream car becomes a showroom reality, engineers have a number of big problems to solve.

One of the engineers' problems—the one Inco Nickel is helping with—is metals. *Heat-resisting metals!*

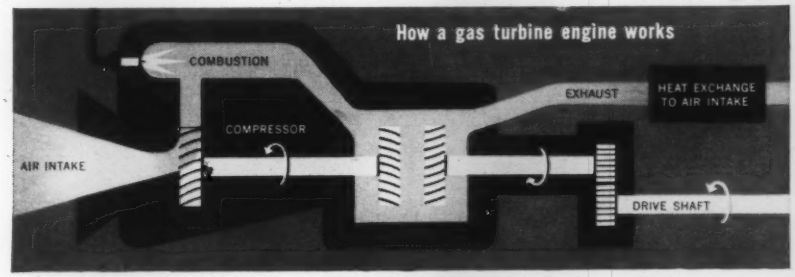
Gas turbine engines operate up to 1600 degrees F. These temperatures step up corrosion. So the job is to develop alloys that can carry the load—that resist corrosion—at these jet-high temperatures.

Nickel-containing alloys are just such metals

This has been proved by (1) International Nickel Company's *basic* research. By (2) the experience of jet engine designers. More proof comes from the research efforts of the automotive and aviation industries . . .

But the uses of nickel-containing alloys *are by no means limited to these industries.* There's a place for them in any field where heat, corrosion, stress and fatigue proves troublesome. Our new booklet, "High Temperatures Spur Use of Nickel-Base Alloys," points up this versatility. Write for a copy.

The International Nickel Company, Inc., New York 5, N.Y.



Inco Nickel

Makes metals perform better longer

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Circle 447 on Page 19→

Get better protection...more reliable

...WITH GENERAL ELECTRIC

operation for your product

TRI 55 CLAD ENCLOSED MOTORS

HERE'S WHY:

External Features: Moisture-resistant sealing compound is applied on carefully machined rabbets to assure better protection against moisture and dust. Corrosion-resistant, non-sparking fan on all enclosed fan-cooled Tri/Clad '55' motors resists action of the strongest acids and alkalis. Jet action cools motor effectively and efficiently for long-life operation.

Lead connections are protected from contact with moisture and dirt by a cork-neoprene gasket between halves of the easy-access conduit box.

Further, a new lead positioner gasket between conduit box and frame is impervious to cutting fluids—protects internal parts effectively.

Internal Features: Mylar* polyester film insulation and Formex† magnet wire provide greater moisture and heat-aging protection. Water-resistant stator coating also guards against failure due to moisture. And G.E.'s advanced bearing system gives years more service.

General Electric offers you the most complete line of enclosed motors in the industry, including standard enclosed, severe-duty (for highly corrosive atmospheres), and explosion-proof motors.

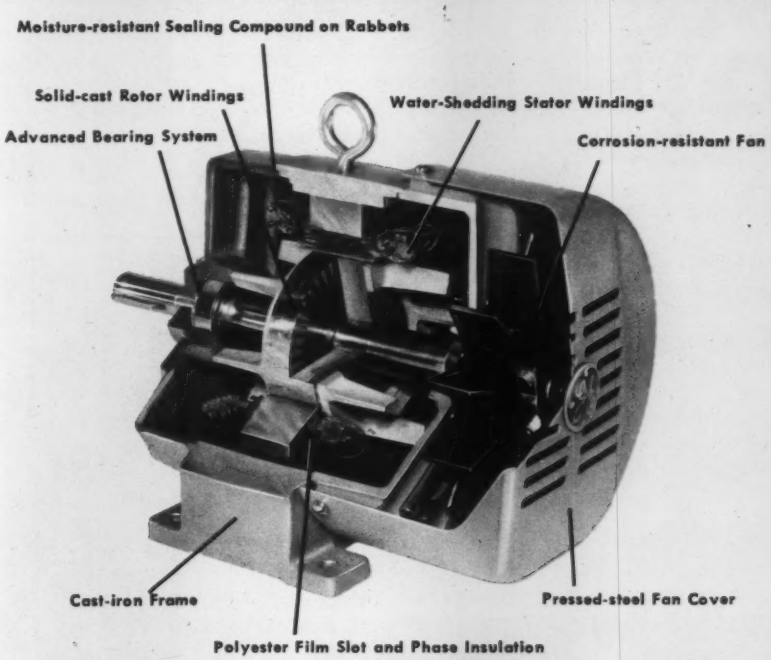
CONTACT your nearest G-E Apparatus Sales Office now for *personal proof* on why G-E Tri/Clad '55' enclosed motors can do a better job for your applications. And ask for a free copy of these descriptive motor bulletins: 1-5 hp—GEA-6240, GEA-5980, and GEA-6341; 7½-125 hp—GEA-6602. Or write for them to Section 840-20, General Electric Co., Schenectady 5, New York.

*Registered Trade-mark of DuPont Co.

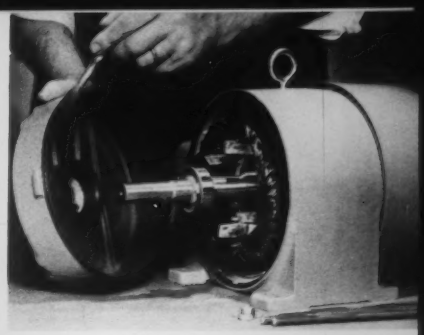
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC

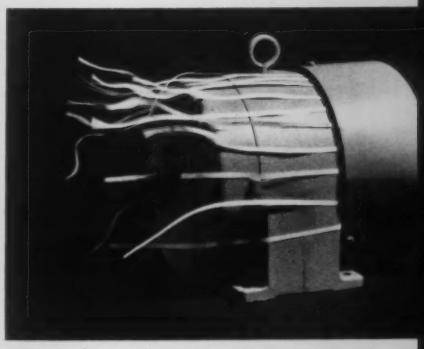
COMPARE THESE TRI 55 CLAD FEATURES



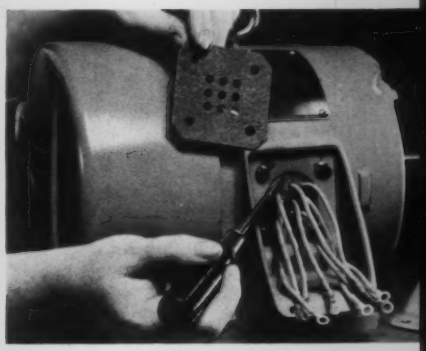
Standard enclosed Tri/Clad '55' motor



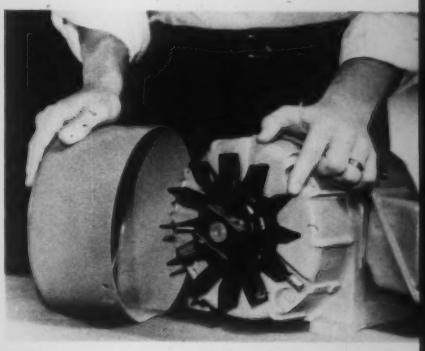
Water-resistant Rabbets protect against moisture, dirt, and abrasive dust for longer life.



Efficient Jet Cooling System spreads a smooth blanket of air over the entire motor frame.



New Lead Positioner and gasket saves connection time; is impervious to cutting liquids.



Non-sparking Fan effectively cools the motor—resists action of strongest acids and alkalis.

NO EQUAL IN SIMPLICITY!

ONLY 3 MOVING PARTS IN ASCO 3-WAY SOLENOID VALVES

Millions of Trouble Free Operations . . . are the result of the simplicity designed into ASCO 3-way solenoid valves. Fewer wearing parts mean substantial savings in maintenance costs...reduction in down-time losses.

Simple in construction, ASCO 3-way solenoid valves are simplicity itself in operation—solenoid piloting of two simple diaphragms. Absolutely tight seating is a feature—no closely fitted parts or valve seat grinding are required.

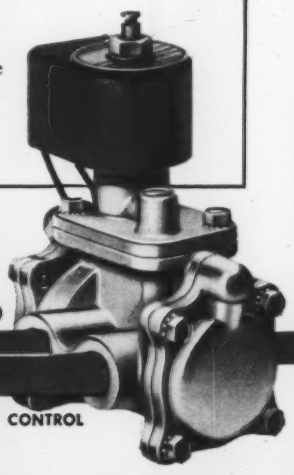
Exceptionally large flow capacity permits rapid filling and venting of cylinders . . . valves operate up to 400 cycles per minute.

Conversion from normally open to normally closed —or the reverse—takes just 30 seconds; only simple rotation of the valve bonnet required.

ASCO 3-way valves can be supplied with general purpose, water tight or explosion-proof enclosures, and may be mounted in any position. Valves are available in 3/8", 1/2" and 3/4" sizes, all with full flow capacity provided by oversize pressure and exhaust orifices. Standard Bulletin 8316 Valves are suitable for air, gas, oil and water at pressures up to 250 p.s.i.; higher pressures can be handled by modified versions.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery . . .
World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.



ASCO®

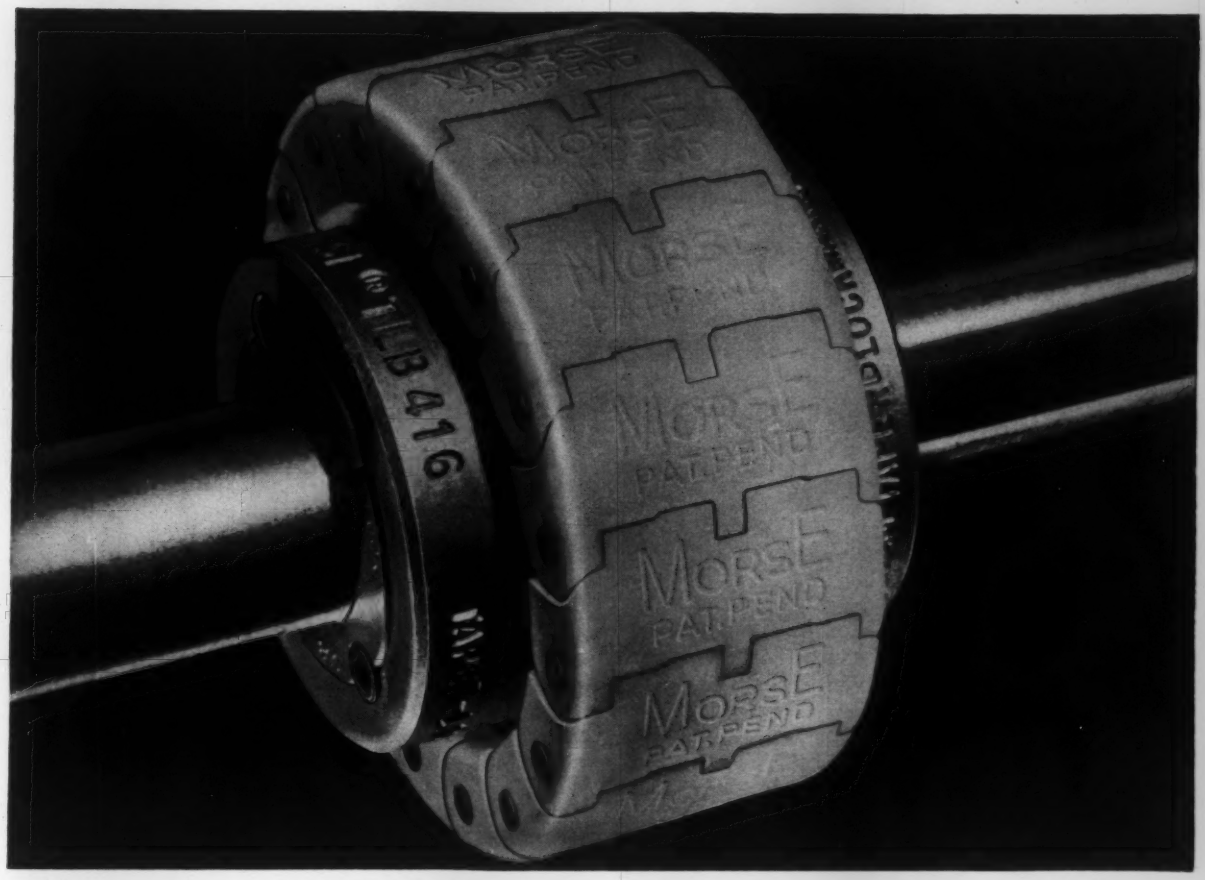
Automatic Switch Co.

54-A Hanover Road, Florham Park, New Jersey • FRontier 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

Circle 448 on Page 19

Now...from Morse Chain



New Nylon Couplings

Cost 20% less, need no lubrication, last indefinitely!

New Morse Nylon Flexible Couplings cost less to buy and maintain than steel couplings. They use economical, stock roller chain sprockets—need no protective cover. They last longer, too . . . operate without lubrication because friction and wear are negligible.

Order complete couplings—½" pitch links plus stock sprockets (plain, finished bore, or taper-lock)—or buy just the links and use your own sprockets. Morse Nylon Couplings, made of Du Pont "Zytel" resin, are ideal for loads from fractional to 40 h.p. and speeds from 500 to 5000 rpm. And they adjust to misalignment.

For facts on Nylon Couplings, or the other couplings in the most complete line ever offered, call your local Morse Distributor. He's listed in the Yellow Pages under "Power Transmission". Or write: MORSE CHAIN COMPANY, DEPT. 6-88, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois.

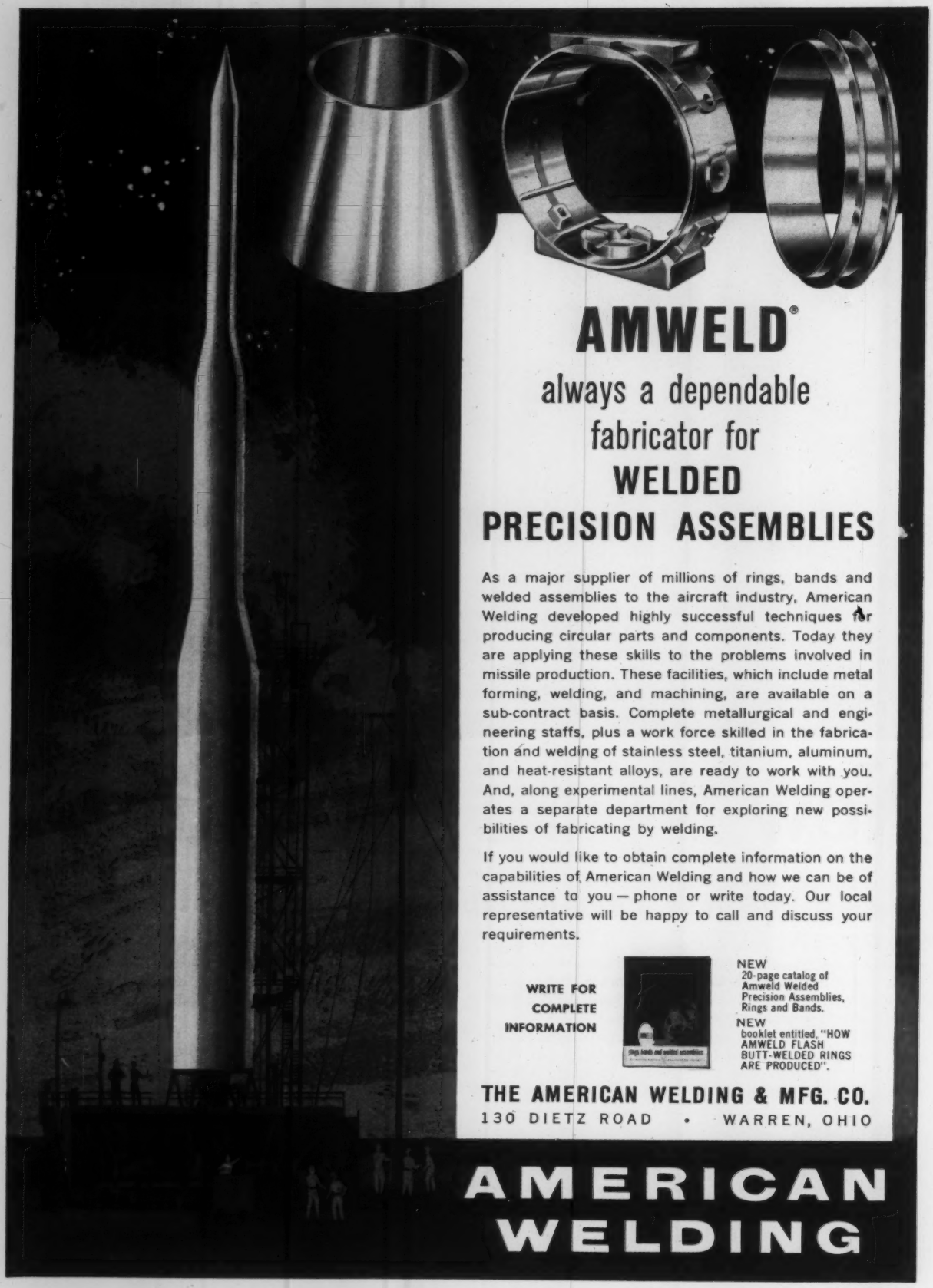
IN POWER TRANSMISSION
THE TOUGH JOBS COME TO

MORSE* BW

*Trademark

REMEMBER: Only Morse offers all four flexible couplings: Chain, Morflex and Radial, Morflex and Radial Driveshafts, and Nylon

Circle 449 on Page 19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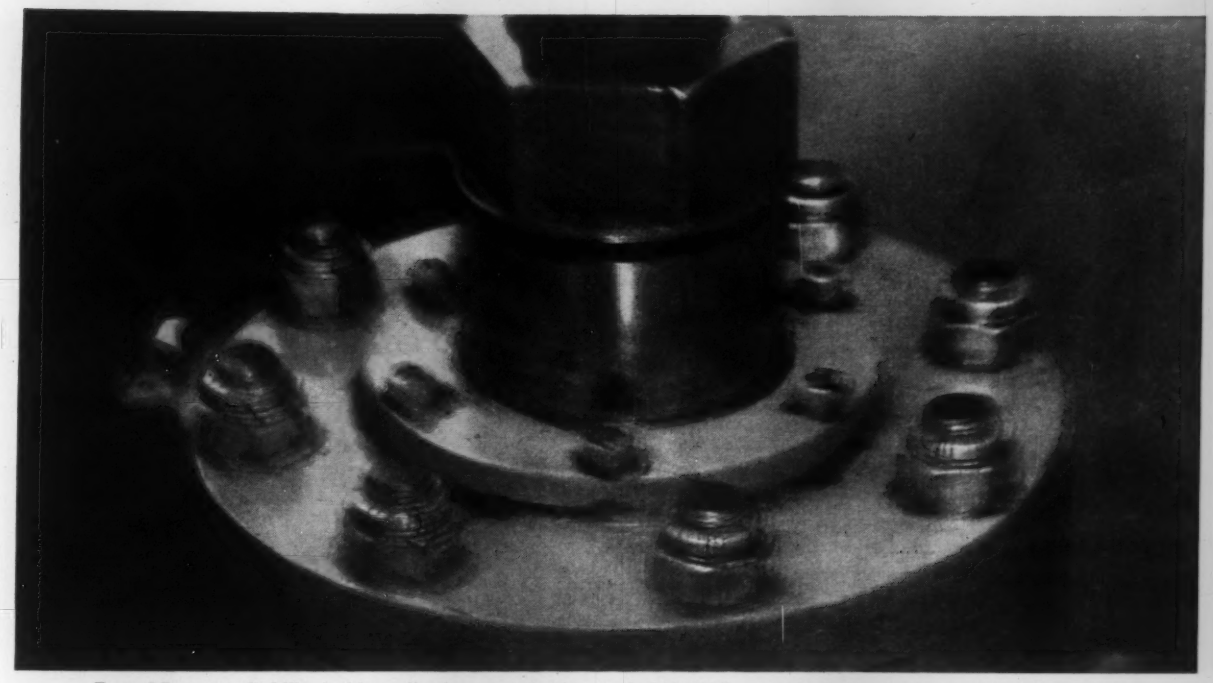
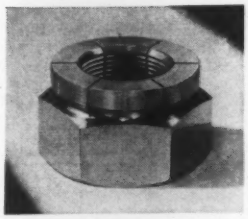
always a dependable
fabricator for
WELDED
PRECISION ASSEMBLIES
As a major supplier of millions of rings, bands and welded assemblies to the aircraft industry, American Welding developed highly successful techniques for producing circular parts and components. Today they are applying these skills to the problems involved in missile production. These facilities, which include metal forming, welding, and machining, are available on a sub-contract basis. Complete metallurgical and engineering staffs, plus a work force skilled in the fabrication and welding of stainless steel, titanium, aluminum, and heat-resistant alloys, are ready to work with you. And, along experimental lines, American Welding operates a separate department for exploring new possibilities of fabricating by welding.
If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today. Our local representative will be happy to call and discuss your requirements.
WRITE FOR COMPLETE INFORMATION
NEW 20-page catalog of Amweld Welded Precision Assemblies, Rings and Bands.
NEW booklet entitled, "HOW AMWELD FLASH BUTT-WELDED RINGS ARE PRODUCED".
THE AMERICAN WELDING & MFG. CO.
130 DIETZ ROAD • WARREN, OHIO
AMERICAN WELDING



Test of FLEXLOC reliability is this application on preload control of 15,000 lb.-capacity fatigue testing machine. Apparatus is capable of 16,000 stress cycles per hour, and individual tests run to millions of cycles. FLEXLOCS do not vibrate loose.

FLEXLOC self-locking nuts stay tight despite impact, shock or vibration



FLEXLOC self-locking nuts offer you a simple, practical solution to the problem of keeping fasteners tight under vibration. Constant jarring, high-speed oscillation, pounding of heavy machinery—nothing will shake them loose. They help give your product the competitive advantage of high reliability, a qualification that is rapidly becoming critical in both industrial and consumer goods.

FLEXLOCS are 1-piece, self-locking units. They require no lockwashers, jam nuts or cotter pins. There is nothing to put together, come apart or get lost; no nonmetallic inserts to come out, deteriorate, or be chewed up by rough bolt threads.

A FLEXLOC goes on like an ordinary nut . . . start it with your fingers, then tighten it with a hand or speed wrench. FLEXLOCS torque easily, never gall or bind. If bolt threads are rough or imperfect, a FLEXLOC tends to smooth them out. As soon as 1½ threads are past the top of the nut, the FLEXLOC is fully locked. It does not have to seat to lock and can be used as a stop nut or a locknut.

Because they require no auxiliary locking elements, FLEXLOC self-locking nuts facilitate design and specification, simplify inventory and handling, reduce assembly time and costs. They also save on maintenance, because they are readily removed and can be reused many times. Expansion of the locking section never exceeds the elastic limit of the metal, so that locking power does not diminish with reuse. See your authorized FLEXLOC distributor for more information. He carries FLEXLOC self-locking nuts in a full range of standard sizes and materials. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

hiRf High Reliability factor

At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic stresses. By using SPS fasteners in your assemblies, you can increase their overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

World's largest producer of precision threaded fasteners / and related products

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 451 on Page 19

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

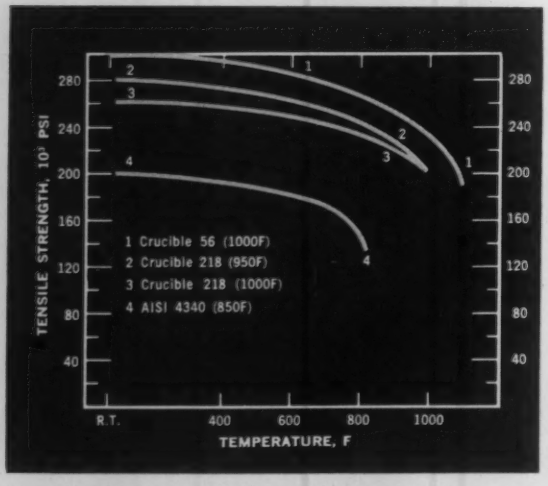


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

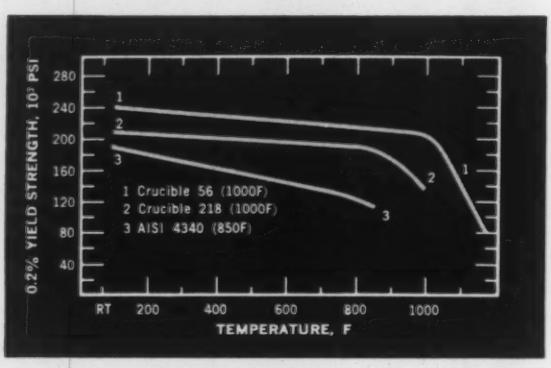


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

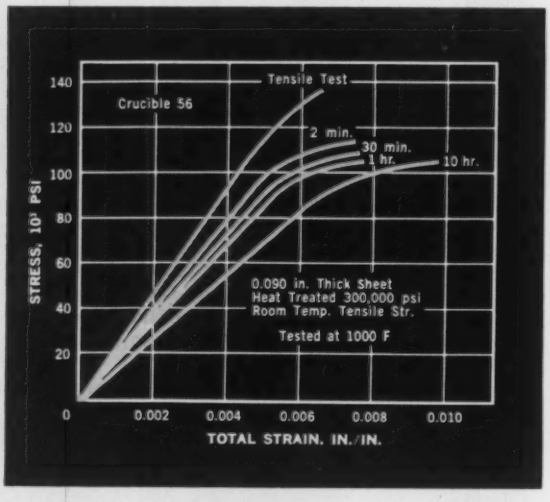


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

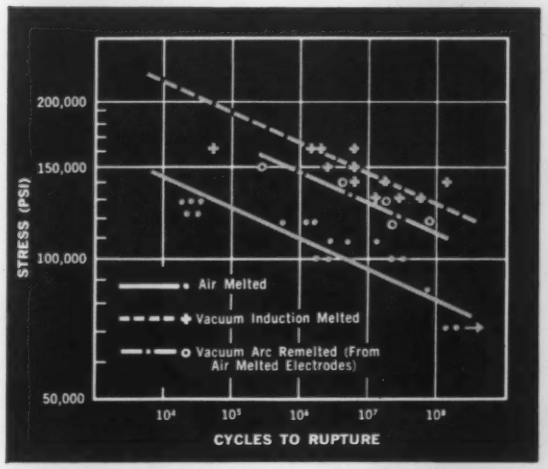
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	< 1
AM+VAR	7	70	< 1
VIM	5	3	< 1
VIM+VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EG07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

Company_____

Street_____

City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 452 on Page 19

It's a Life Saver

because this sensitive

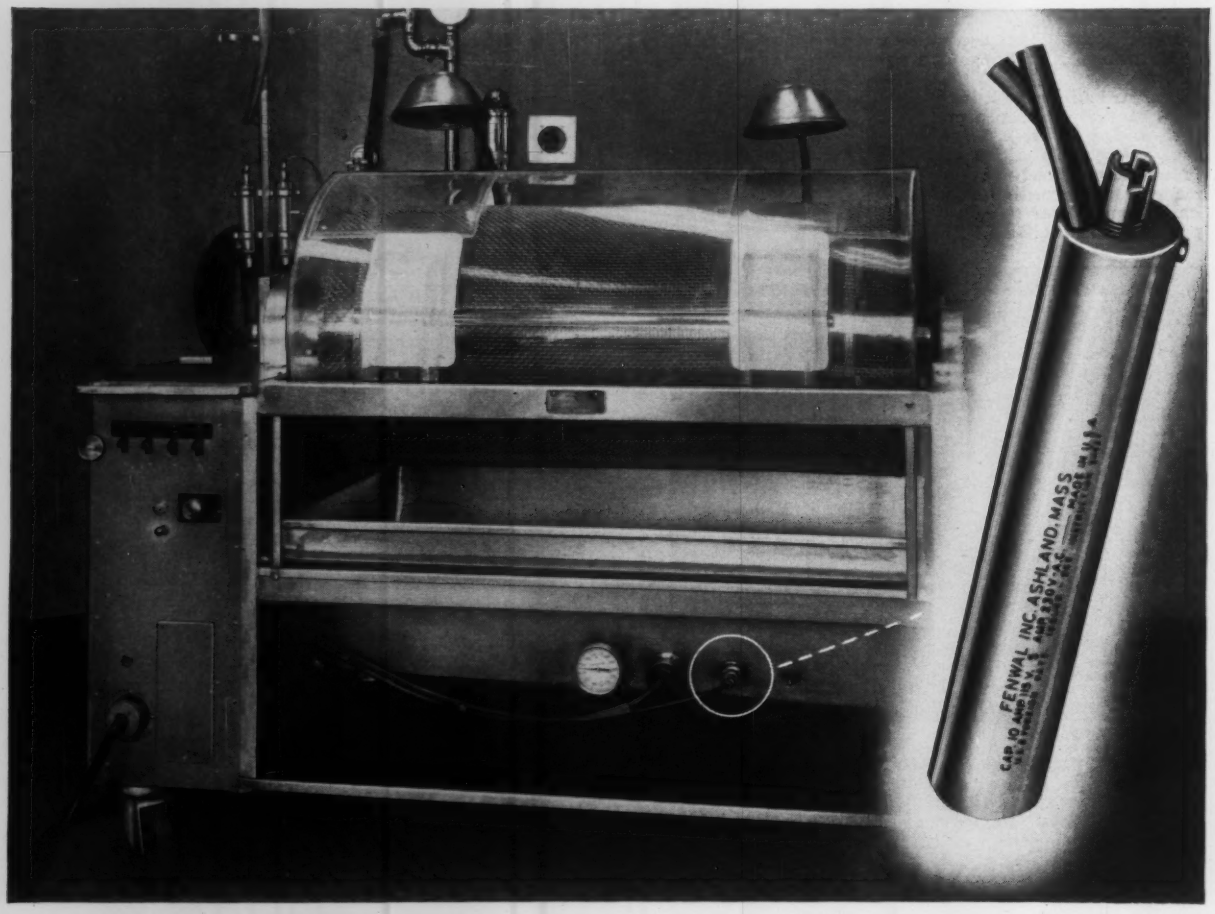
Fenwal THERMOSWITCH® unit controls temperature precisely

Where precise control is necessary, customers have been relying on Fenwal THERMOSWITCH Temperature Controls for years. That's because Fenwal THERMOSWITCH units are extremely sensitive and they last. Consistently they provide one half million cycles or more of precision temperature control. *You get reliability!*

The entire shell is the sensing element of THERMOSWITCH units, giving more heat responsive area and faster reaction to temperature change. This, plus a design based on differential expansion of metals, gives control in fractions of degrees. *You get precision control!*

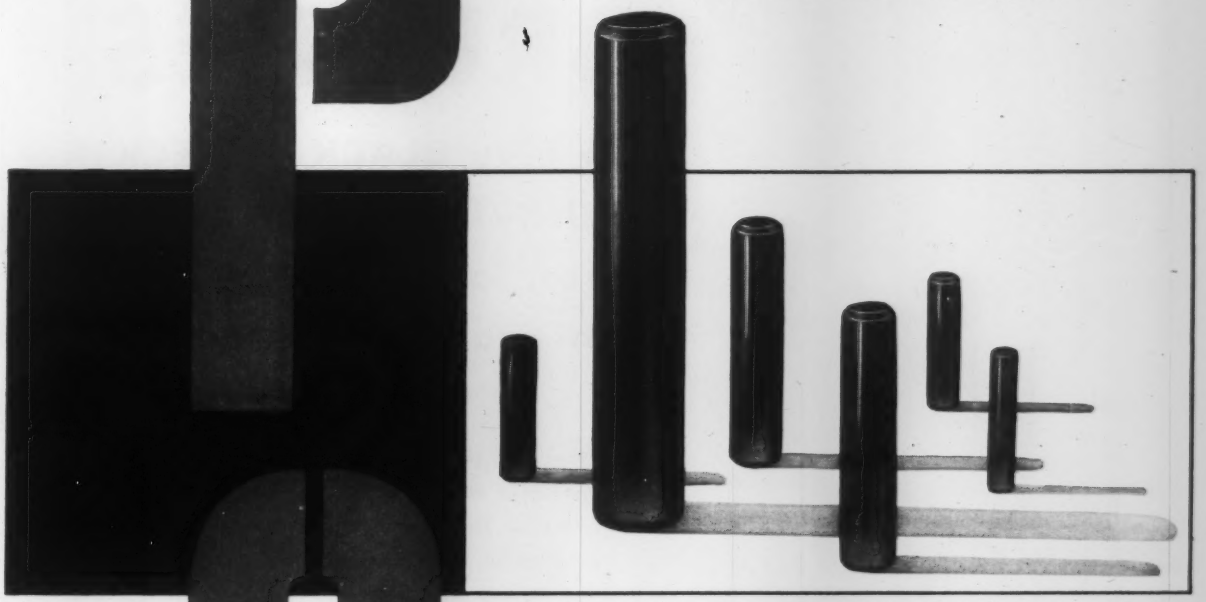
Fenwal THERMOSWITCH units can help your equipment run faster, require less maintenance, and be more flexible. For information on the model best for your application, write to Fenwal Incorporated, 198 Pleasant Street, Ashland, Massachusetts, and we'll send you our catalog MC-135 or a sales engineer, whichever you want.

This is our series 17000 in an artificial kidney. This medical equipment has been instrumental in saving the lives of many people suffering from uremic poisoning. Each time the patient's blood passes through the artificial kidney, more poison is filtered out. The Fenwal THERMOSWITCH unit controls the rinsing bath so-that blood returns to the patient at body temperature.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

Problem: *"Mating parts in a machine tool fixture must be accurately positioned and held in absolute relation to each other. Fixture must absorb lateral thrusts. Must be dis-assembled and re-assembled in exact relationship . . ."*



Solution: *HOLO-KROME DOWEL PINS. Made of special analysis alloy steel with a surface hardness of 60-64 Rockwell "C" and a core hardness 50-54 Rockwell "C". Machined .0002" oversize for press fit between mating parts; .001" oversize for repair work or where holes have been machined oversize. A microinch finish of 6 RMS maximum assures accurate positioning to close tolerances. Shear strength of 150-170,000 p.s.i. absorbs side pressures and lateral thrusts without movement of parts. The famous H-K black lustre finish retards corrosion, facilitates driving.*

HOLO-KROME SOCKET SCREWS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

For the finest in Hex Socket Screws . . . for unmatched Same-Day Service, the name to remember is Holo-Krome.

Circle 454 on Page 19

BRUSHES

help give BLACK & DECKER INDUSTRIAL TOOLS power, long life, maintenance-free service

For more than forty years Black & Decker electric tools have been recognized by users as the most dependable and adequate tools of their kind. This reputation has been earned through rigid quality control, intensive research, testing and design engineering. To help make these tools first in performance and quality the world over, Black & Decker specify USG motor brushes. (Some of the industrial electric tool applications are pictured here.)

United States Graphite Company (USG) brushes are giving excellent service not only in Black & Decker products, but also in hundreds of installations, large and small, throughout industry. Because the brushes in any electric powered unit are so vital to the long life, power and maintenance-free service of that unit, it pays to specify USG brushes of carbon, carbon-graphite, electro-graphite, graphite, metal graphite or silver graphite.

Write for catalog B-56 and the USG grade list. Most of the information necessary to design engineers is contained in these two books.

B-246-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 455 on Page 19

Decks of cards replace acres of files

New Recordak Engineering drawing system simplifies filing, reference, printmaking and print distribution . . . seems destined to change drafting-room procedures the world over.

An exclusive Recordak development. New microfilming techniques and quality-control methods perfected by Recordak give results never before achieved in 35mm microfilming. These pictures are of such outstanding quality they increase the scope of Filmsort aperture cards . . . supplant use of bulky blueprints and drawings in many drafting-room routines.

Just how do these new Recordak pictures differ from others?

In one important way—now, all types of drawings, prints, specification sheets—negatives or positives, old or new, clean or dirty—can be reproduced uniformly on low-cost 35mm Recordak microfilm *without loss of detail!* Important, too—enlargements made from them are as readable as the originals.

The next step in the Recordak System—mounting these superb Recordak reproductions on individual cards puts complete drawing files at fingertips . . . saves engineering time, steps up efficiency. Large organizations can realize further economies by correlating their use with existing mechanized filing, duplicating and enlarging systems.

See how new Recordak System helps: Files cut 95% • Any picture can be checked immediately in Film Reader • Microfilm cards can always be filed in any numbered sequence • Paper prints or duplicates made rapidly by photographic or electrostatic method • Branches, subcontractors supplied at lowest cost.

FREE BOOKLET tells how this System can work for you. Includes sample Recordak Microfilm frame mounted on Filmsort aperture card. Mail coupon today.

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Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever. II-8

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Address_____

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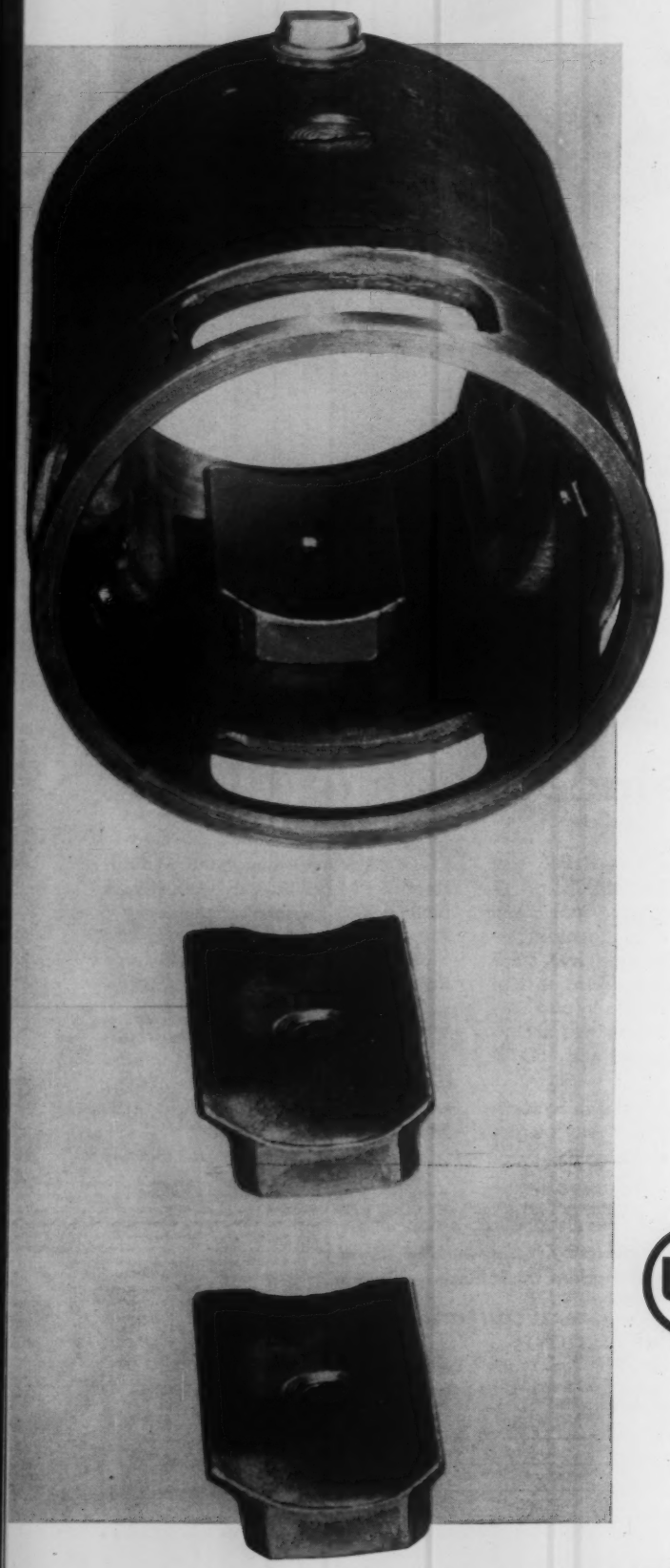
STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



Auto starter pole shoes by the thousands—

made from steel already rolled to shape!

An automobile parts manufacturer produces thousands of automobile starter motors daily. Each one takes four pole shoes. To machine these parts from rectangular bars or to use built-up laminations was too slow and too costly.

They solved the problem by making the pole shoe from USS Special Section Rolled Steel Bars. The cross section of the bar is rolled so close to that of the pole shoe that no machining is required. They merely shear the shoe to length, punch the mounting hole, clean and tumble, coin to obtain precise curvature, and tap the hole.

These operations are set up on a mass-production basis and pole shoes come tumbling out at a rate of 11,000 per day, or more. There's very little scrap and unit costs have been reduced to a minimum.

Why not find out what USS Special Sections can do for you? For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

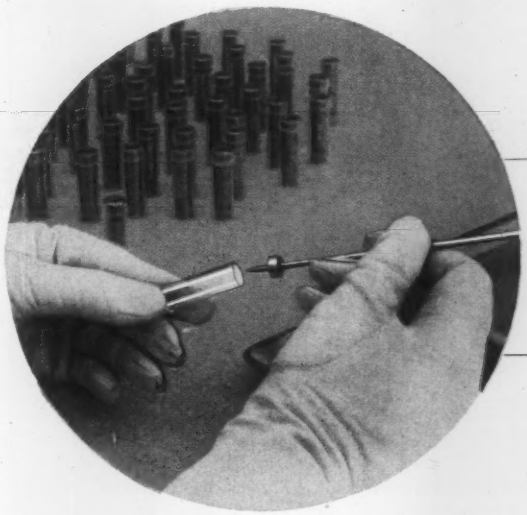
A better product at lower cost when pole shoes are manufactured from USS Special Section Bars.

United States Steel Corporation – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

USS

United States Steel

WITH FAFNIR MINIATURE BALL BEARINGS YOU GET ALL FIVE IMPORTANT FEATURES



1 **VACUUM MELT 440C.** Balls and rings of Fafnir miniature bearings are made from vacuum melt 440C stainless steel.

ADVANTAGES. Since vacuum melt steel is extremely clean, balls and races are free from pits and inclusions providing better finishes which result in super sensitive bearings with low torque values.

2 **BALANCED DESIGN.** Each size bearing has its "tailormade" retainer of predetermined weight and dimensions.

ADVANTAGES. Pitch circle of the balls is centered between bore and O.D. and bearing is symmetrical in design.

3 **HARDENED RETAINERS.** All retainers are made of hardened 410 stainless steel.

ADVANTAGE. Precise hardening, insured against brittleness and easy breakage by quality control, provides springiness... eliminating bending or distortion.

4 **SWAGED RETAINERS.** In manufacture retainers are swaged so that ball pockets of retainers are ironed outwardly.

ADVANTAGE. Ball runs against a hardened, smooth surface not a rough edge.

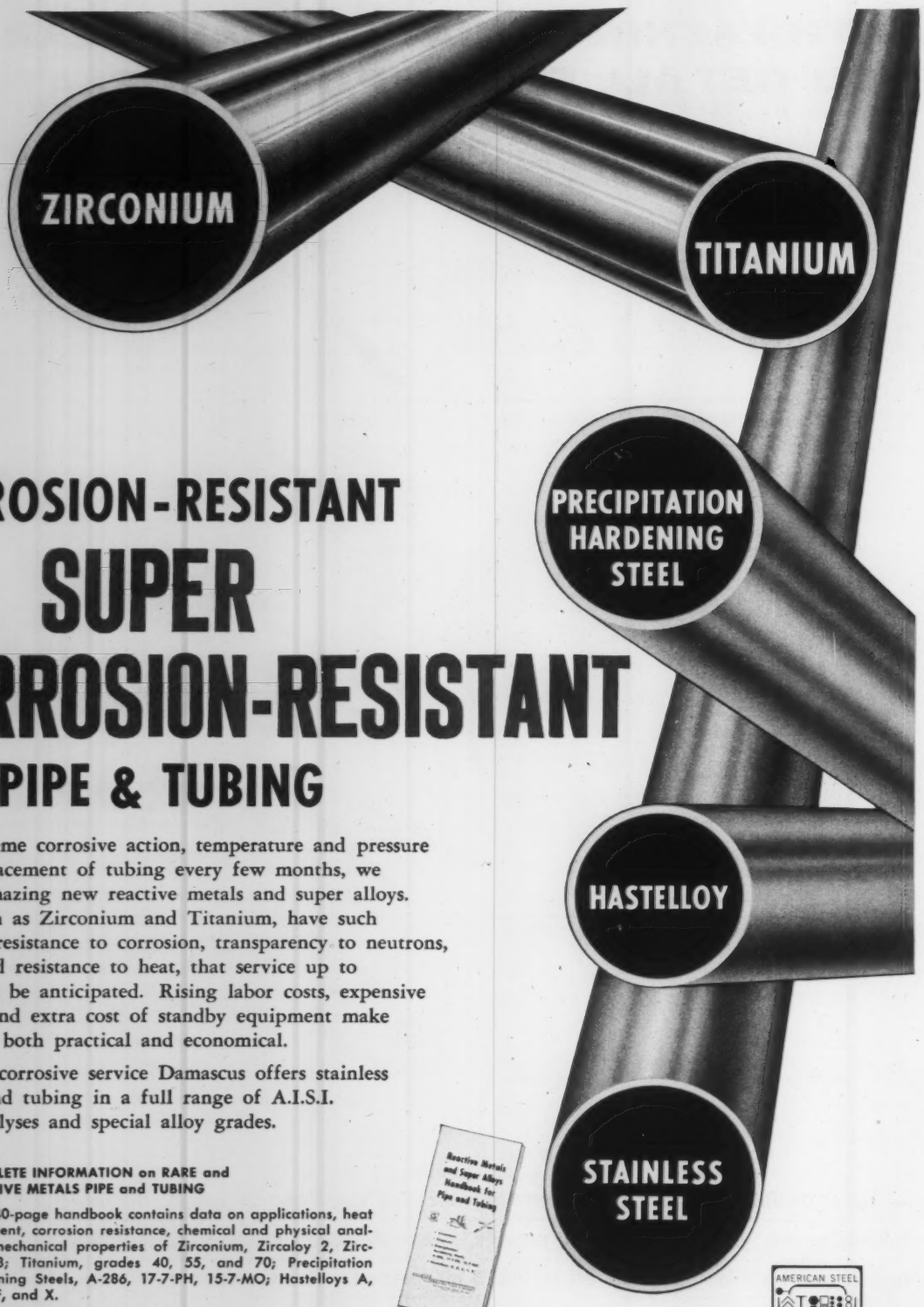
5 **HEAT STABILIZATION.** All rings and balls are heat stabilized to 600 degrees.

ADVANTAGE. Standard Fafnir bearings may be used for high temperature applications as well as regular applications.

All Fafnir miniature bearing tolerances are to ABEC-7 standards except for the inner ring bores where tolerances are +.0000 —.0002 to provide greater flexibility in selective assembly. Bearing balls are lapped to 2.5 millionths for sphericity and 5 millionths for size variation. Fafnir Miniature Ball Bearings are available in the following types: open; flanged; two shields and flanged two shields. Complete details and dimensions in bulletin No. 469. Write for copy. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
Most Complete Line in America

Circle 457 on Page 19



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Where extreme corrosive action, temperature and pressure require replacement of tubing every few months, we offer the amazing new reactive metals and super alloys. Several, such as Zirconium and Titanium, have such remarkable resistance to corrosion, transparency to neutrons, strength, and resistance to heat, that service up to 20 years can be anticipated. Rising labor costs, expensive down-time and extra cost of standby equipment make these metals both practical and economical.

For general corrosive service Damascus offers stainless steel pipe and tubing in a full range of A.I.S.I. standard analyses and special alloy grades.

COMPLETE INFORMATION on RARE and REACTIVE METALS PIPE and TUBING

New 40-page handbook contains data on applications, heat treatment, corrosion resistance, chemical and physical analysis, mechanical properties of Zirconium, Zircaloy 2, Zircaloy 3; Titanium, grades 40, 55, and 70; Precipitation Hardening Steels, A-286, 17-7-PH, 15-7-MO; Hastelloys A, B, C, F, and X.

AMERICAN STEEL WAREHOUSE ASS'N

FORMED STEEL TUBE INSTITUTE

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STAINLESS STEEL TUBING AND PIPE

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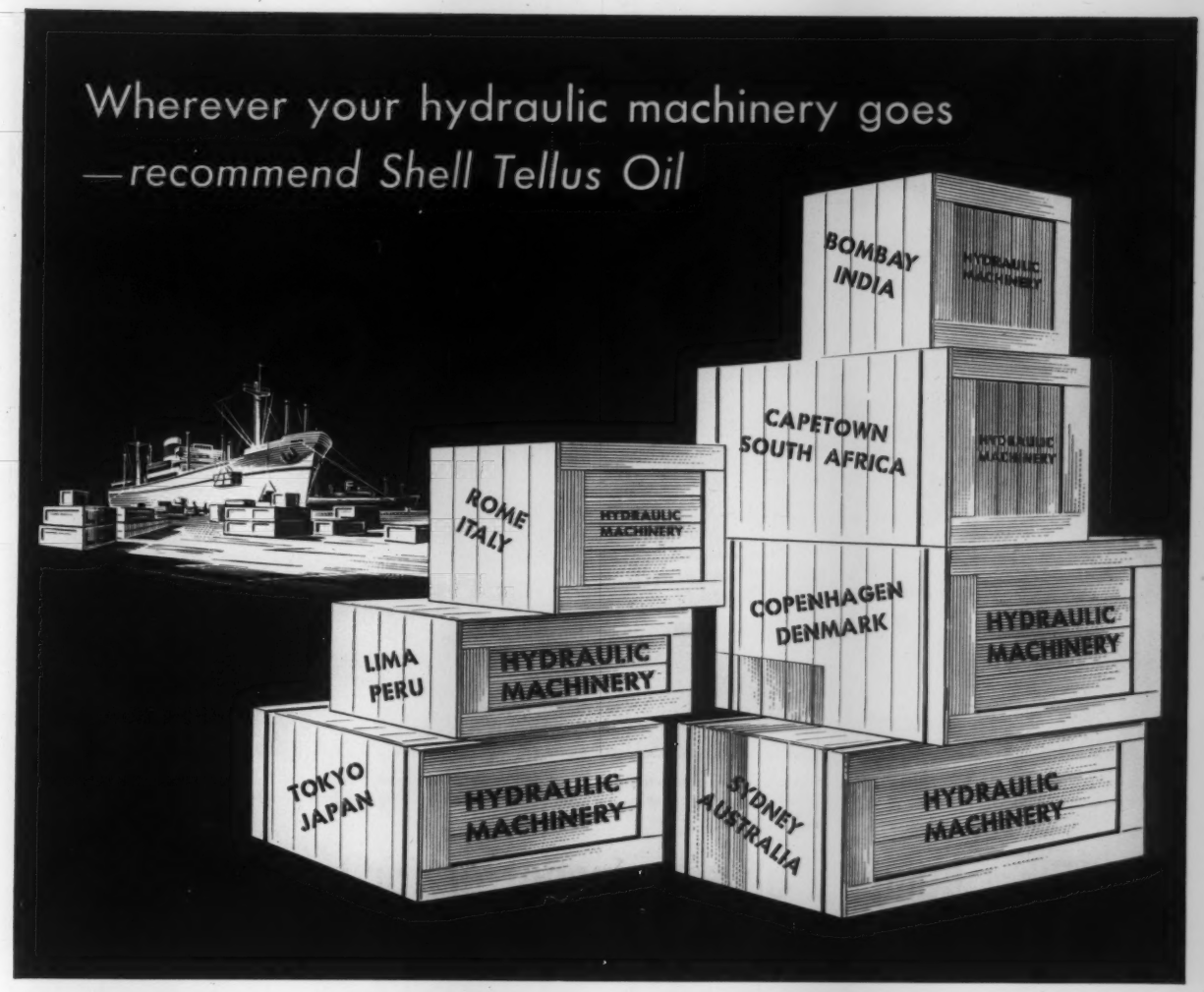
Circle 458 on Page 19



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Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

Shell Tellus Oil is top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge-formation, wear and foaming has earned it nationwide popularity.

You may be glad to know that the hydraulic-operated equipment you manufacture can now obtain the same efficient protection in other countries of the world. Tellus* Oil is available to your customers abroad. With it they can enjoy the same performance that your domestic customers rely upon.

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SHELL TELLUS OIL

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Circle 459 on Page 19

Republic ELECTRUNITE Mechanical Tubing is used in four locations across the top of the automatic apparatus that picks up and sets the bowling pins in place. The AMF Automatic Pinspotter is manufactured by the American Machine & Foundry Company, Brooklyn, New York.

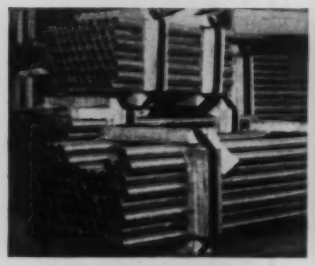
AMF . . . builds a better pinspotter for better bowling with Republic ELECTRUNITE Mechanical Tubing

On the initial order, Republic ELECTRUNITE® Mechanical Tubing saved American Machine & Foundry Company $34,000 in manufacturing their famous AMF Automatic Pinspotter.

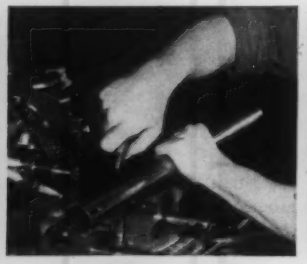
AMF had been using tubing that required a boring operation on each end of the tube and centerless grinding on the O.D.

Because Republic's ELECTRUNITE Mechanical Tubing met AMF's O.D. tolerance requirements, the company was able to eliminate the boring and grinding operations. This resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with the tubing used previously.

In uniformity and quality, in fabricating, in original costs, Republic's ELECTRUNITE Mechanical Tubing can save you time and money, too! Call your Republic representative, or write today.

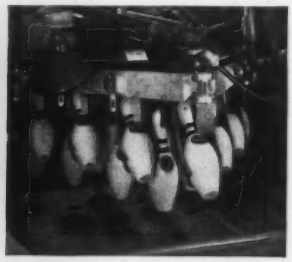


Republic ELECTRUNITE Mechanical Tubing is delivered, cut to length, ready for fabricating. ELECTRUNITE Tubing is "electrically welded" resulting in built-in uniformity.



Slots to hold spotting cups in place are cut into ELECTRUNITE Tubing by machine. Concentricity of the ELECTRUNITE assures easy fabrication and smooth mechanical operation.

Drilling and cutting complete, the ELECTRUNITE Tubing is ready for assembly. Lightweight ELECTRUNITE offers uniform wall thickness, strength, ductility for greater serviceability.



Sensitivity in setting off-spot pins is the result of design and engineering, highest quality workmanship, and highest quality materials, such as Republic's ELECTRUNITE Tubing.

REPUBLIC NYLOK® FASTENERS SAFEGUARD PERFORMANCE SPECIFICATIONS. Republic fasteners are used extensively on Gemco Rotary, Reel, and Riding Power Lawn Mowers. Inset shows blade assembly securely locked to engine shaft with Nylok Cap Screw. An added advantage of Republic Nylok Bolts and Cap Screws is their ability to seal against fluid escape when wrenched tight. Nylon pellet in bolt body blocks flow of fluid along helical threaded path. Send for data.

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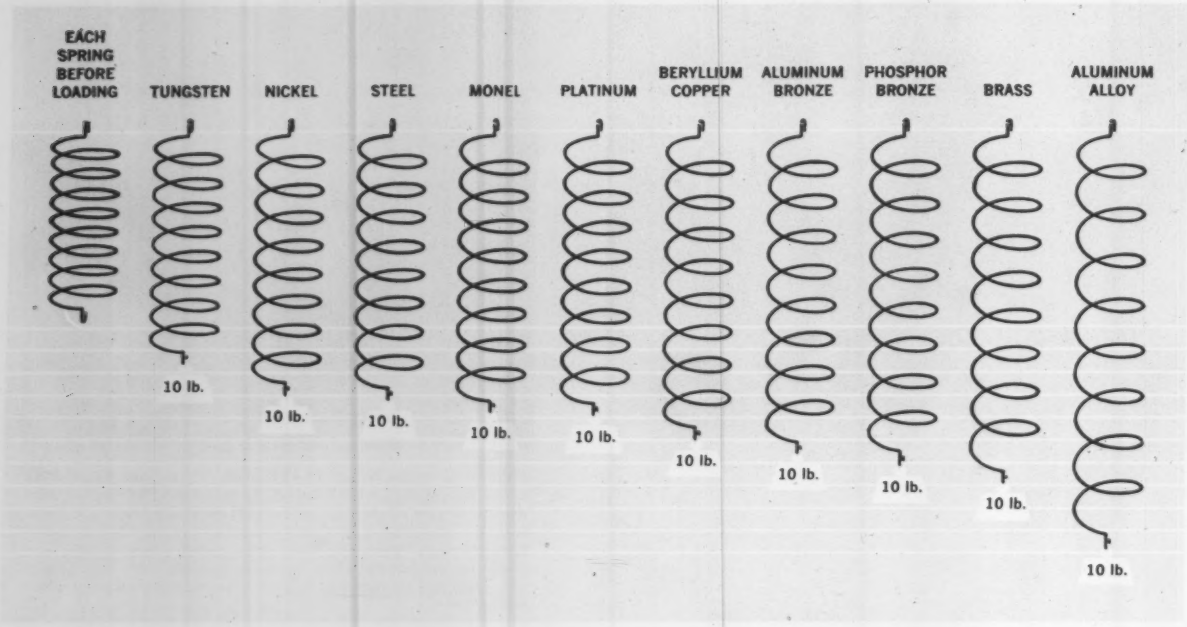
Circle 460 on Page 19



How much deflection do you want in a spring?

The wide range of stiffness characteristics available in different materials offer unusual opportunity to solve spring deflection problems. How wide is shown in the chart above. The tension springs are all of identical dimensions but of different materials and indicate the relative deflection obtained from applying the same load (assuming the stresses are within safe limits). This basic principle is often overlooked in the approach to spring selection not only of extension springs but other types: flat, torsion, etc. Because our daily work includes such a wide range of spring usage, we are in a position to help you in the early stages of spring consideration, both in material selection and production short cuts. A handy pamphlet to have at your elbow is our "Metal Selector." Write for your copy.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
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Dunbar Brothers Division, Bristol, Conn.
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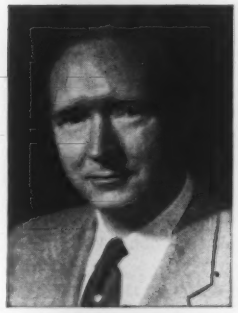
5806

MACHINE DESIGN
August 21, 1958



Bargaining by Press Release

LIKE it or not, unionization of engineers seems here to stay. But given a stronger show of interest by management in the problems of the engineer, and a more professional attitude among engineers, union representation may never affect more than a minority of engineers.

We cannot help but feel that the existence, and relative success, of engineering unions are symptoms of a failure in communications. What should be matters of private negotiation between professionals are dragged into public view, when a union takes over the bargaining responsibility.

As soon as the public is let in on the negotiations, the temptation to use propaganda to enlist public sympathy becomes well-nigh irresistible. When that happens, any pretense that engineers are professionals in a confidential relationship with their employers goes out the window.

A favorite propaganda gambit is to pile impossible demand upon impossible demand, then make a great show of willingness to cooperate by relinquishing these objectives one by one. Soon an impressive list of concessions has been made, while the other side, not having built its case in similar fashion, has very little to retreat from.

Then the propaganda guns open up. Shrill cries accuse the other side of failure to bargain in "good faith." It is implied that bargaining isn't in good faith unless each side gives in an approximately equal amount.

Such transparent tactics — which certainly do not demonstrate good faith—serve simply to widen the breach and diminish the possibility of re-establishing good lines of communication. Let's hope that engineering unions will recognize the hazards of this sort of "bargaining by press release."

Colin Carmichael

EDITOR

By EVERETT WOERTER, Manager, Standards Dept.
Engineering Services Laboratory, American Machine & Foundry Co., Stamford, Conn.

Putting Standards To Work

Organizing an effective standards program is no small undertaking in any engineering operation. But when the efforts of a number of companies and facilities with diverse product interests must be co-ordinated, the job can take on immense proportions. Such a problem is faced by American Machine & Foundry Co. which is made up of 39 plants and 13 engineering laboratories in the United States and Canada. The solution: A flexible program designed to insure the development of company-wide and local standards that satisfy the needs of each organization, regardless of product line and scope of operation. How the program works and what it has accomplished are discussed in this article. Although considered from the viewpoint of a multiple-plant operation, concepts presented here may prove equally valid in companies of any size.

TO BE effective, standards should reflect what can be accomplished rather than what should be done. They define the present state of knowledge and live only so long as they continue to serve this function. Standards help to co-ordinate the efforts of separate groups that may be involved in different phases of the same problem, and they promote consistency in the handling of repeated functions while providing answers to repetitive questions.

Standardization enables the buyer and seller to speak the same language and it compels competitive sellers to do likewise. In addition, by putting vendors on an easily comparable basis it promotes fairness in competition. It lowers unit costs to the public by making mass production possible. By simplifying the carrying of stocks, it makes deliveries quicker and prices lower. It eliminates indecision, a prolific cause of inefficiency and waste in production and utilization. Standardization helps to eliminate practices which are merely the result of accident or tradition and which tend to impede progress and development. As final authority, standards eliminate confusion caused by differences of opinion.

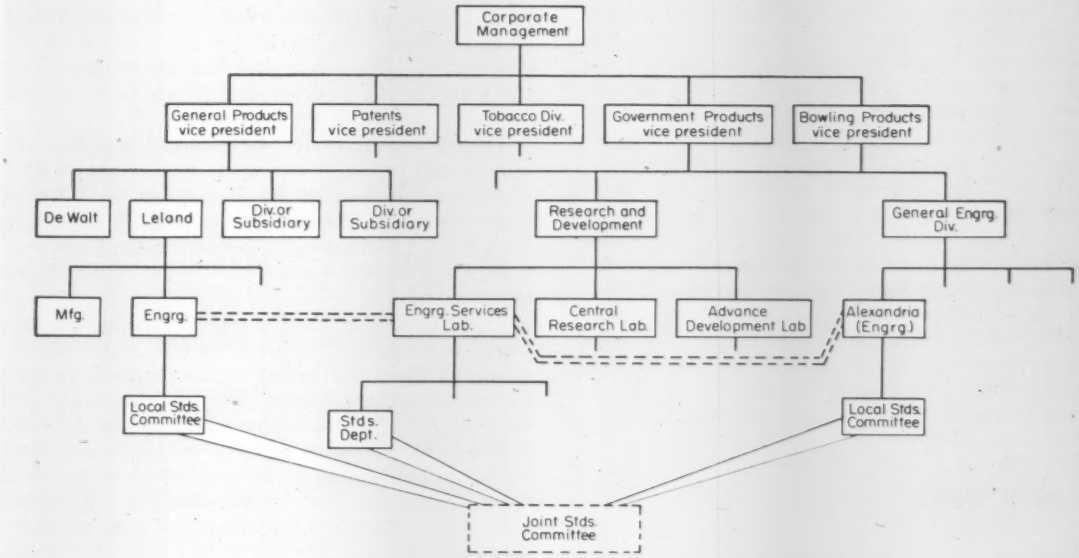
Standards are particularly essential when parts and subassemblies are mass-produced in a number of widely separated plants and, possibly, by subcontractors, and shipped to another location for final assembly of the end product. They facilitate manufacturing and inspection, and insure proper fit and interchangeability of parts. Thus, good design, modern production and assembly techniques, plus the proper application of standards, all aid in the efficient manufacture of any product.

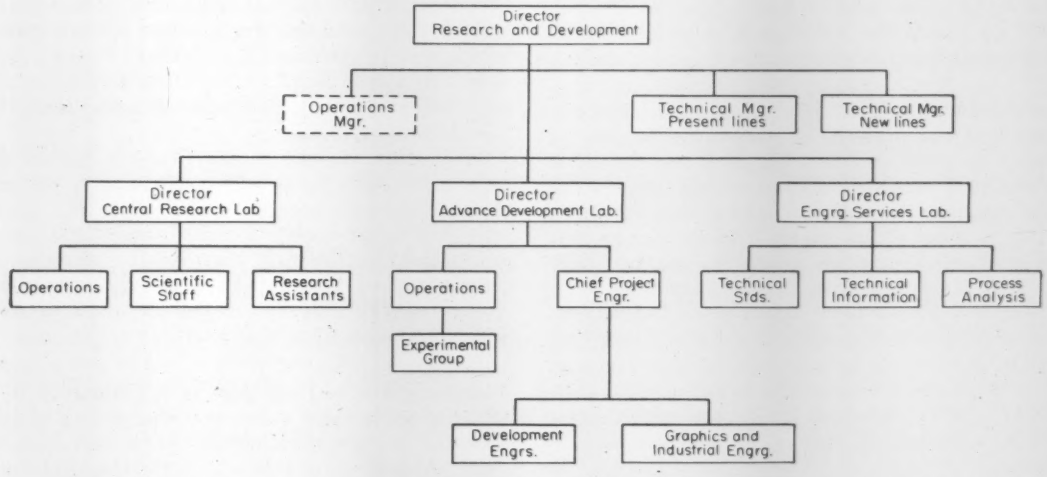
Organization of Standards Program

American Machine and Foundry Co. classifies its output according to products for consumers, industry, defense, and atomic energy. It is necessary that their standards be adaptable to the manufacture of atomic research reactors as well as to automatic Pinspotters for bowling alleys and pretzel-tying machines for bakeries.

The standards program at AMF is under the direct

Details of a flexible program for co-ordinating standards activities in large and small organizations





Organization charts at corporate and division levels of American Machine and Foundry Co. illustrate position of standards groups in company structure. The Standards Department is a function of the Engineering Services Laboratory under the Director of Research and Development. Each location or plant has its own local standards committee. General review body is the Joint Standards Committee which is responsible for the overall company standards program. Its chairman is the manager of the Standards Department.

supervision of top management. In the corporate organization, the Standards Department is responsible to the Vice President for Engineering, through the Director of the Engineering Services Laboratory and the Director of Research and Development. Working within the Standards Department, which has fixed membership and a permanent headquarters, is the Joint Standards Committee, which has a flexible membership and a shifting base of operations.

To insure the formulation of standards that are of value to each of the company divisions and subsidiaries regardless of product line, proposed standards are reviewed by the Joint Standards Committee which comprises engineering and manufacturing representatives from each of the company facilities. Their review is based on the premise that "there is no value in standards merely for the sake of standardizing." Standards have value only when their establishment results in economy, simplifies operations, or safeguards persons or property. In other words, standards have actual value only when the money invested in them is returned with interest.

Since the standards program is a company-wide effort, the joint committee holds meetings on alternate months, with a different plant or subsidiary acting as host for each meeting. This interchange gives each of the committee members the opportunity to observe the operation of all other company facilities. As a result, members gain a much better understanding of the overall standards effort. The meetings are conducted as informal conferences, with the Manager of the Standards Department or his designee acting as moderator or conference leader.

How It Works

A request for a standard may be originated by any person, department, or location by submitting the pertinent information to the local standards representative. He, in turn, evaluates the information and, if he agrees that the request is valid, submits it to the Joint Standards Committee for consideration.

Local Standards: If the Joint Standards Committee decides that the problem is of exclusive interest to a particular plant or operation, it is recommended that the local standards committee make an investigation with the view of issuing a local standard. Each location or plant within the organization has its own local standards committee which is concerned only with problems pertinent to its own operation.

There will always be a need for local standards, since, for example, fabrication and process specifications for the manufacture of explosionproof motors will certainly differ from standards and specifications necessary for the manufacture of, say, power saws. All local standards are printed on white paper.

Joint Standards: On the other hand, the committee may recognize the need for a joint standard in the light of the following criteria: 1. Are the presented needs of a recurring nature? 2. Will such a standard be practical? 3. Will it yield a profit?

Having determined the need for a joint standard, the committee then establishes its scope and definition.

The Standards Department, with its limited personnel and limited understanding of local problems, cannot be expected to have the universal knowledge or time to develop standards in the many specialized fields throughout the whole company. Therefore, sponsorship is assigned to a committee member who is familiar with the subject and who is best qualified to prepare a tentative standard.

While compiling data, the sponsor may find it necessary to organize subcommittees and consult specialists or companies having specific interest or experience in the field relating to the subject matter being proposed for a standard. Maximum consideration is given to nationally recognized industrial and technical society standards and specifications as well as to standards and specifications developed by the government. Whenever practical, the sponsor limits his activities to co-ordinating material from such sources.

The sponsor translates the compilation of data and information into a clear, logical, and workable draft which resembles as closely as possible the intended final standard. This paper is submitted to the Joint Standards Committee for review, and any revisions made by the committee are incorporated into the standard.

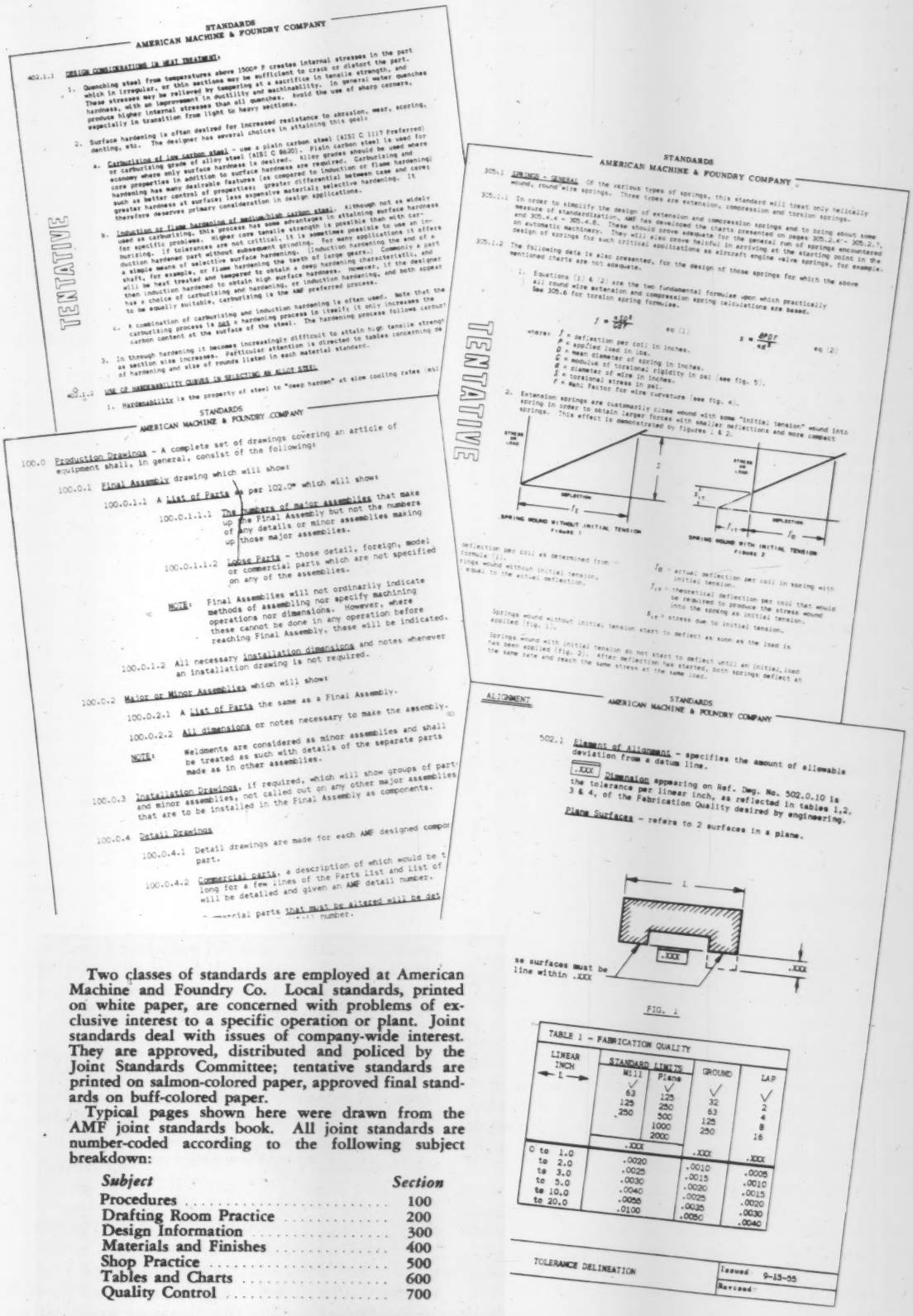
The standard is then printed on salmon-colored paper and labeled "tentative" in bold type. An explanatory sheet is attached to the standard, inviting comments, suggestions, etc., from the people who will have to live with this standard and use it daily. It is then distributed to everyone who has a standards book and field-tested for a predetermined period of time. After the trial period, the Joint Standards Committee reviews all comments and suggestions before approving the printing of the final joint standard on buff-colored paper.

The field-test procedure has proved invaluable. Standards at AMF are not mandatory. Management feels that the final test of a standard is the degree to which it is accepted and used without external pressures. It should be of such obvious desirability and its benefits should be so completely self-evident that it requires no policing.

From this viewpoint, the field-test period has proved its value by providing complaints and suggestions from the people directly concerned. Standards are more readily accepted when the people using them realize that they have a voice in the preparation of the ultimate document. Its subsequent reworking by the committee tailors it to fit into normal job routine as smoothly as possible.

Standards prepared for local use are reviewed constantly by the Joint Standards Committee in an effort to apply them to solution of problems of other facilities or companies within the overall organization. As a result of this practice, many local standards, with slight modifications, have become joint standards.

It is the Standards Department's responsibility to keep abreast of all revisions and additions to technical society and industry standards. Periodically, all AMF standards are reviewed by the joint com-


STANDARDS
AMERICAN MACHINE & FOUNDRY COMPANY

TENTATIVE

402.1.1 DESIGN CONSIDERATIONS IN HEAT TREATMENT:

1. Quenching steel from temperatures above 1500° F creates internal stresses in the part which in irregular, or thin sections may be sufficient to crack or distort the part. These stresses may be relieved by tempering at a sacrifice in tensile strength, and hardness, with an improvement in ductility and machinability. In general water quenches produce higher internal stresses than oil quenches. Avoid the use of sharp corners, especially in transition from light to heavy sections.

2. Surface hardening is often desired for increased resistance to abrasion, wear, scoring, denting, etc. The designer has several choices in attaining this goal:

a. Carburizing of low carbon steel - use a plain carbon steel (AISI C 1117 Preferred) or carburizing grade of alloy steel (AISI C 8620). Plain carbon steel is used for economy where only surface hardness is desired. Alloy grades should be used where core properties in addition to surface hardness are required. Carburizing and hardening has many desirable features (as compared to induction or flame hardening) such as better control of properties; greater differential between case and core; greater hardness at surface; less expensive material; selective hardening. It therefore deserves primary consideration in design applications.

b. Induction or flame hardening of medium-high carbon steel. Although not as widely used as carburizing, this process has some advantages in attaining surface hardness for specific problems. Higher core tensile strength is possible than with carburizing. If tolerances are not critical, it is sometimes possible to use an induction hardened part without subsequent grinding. For many applications it offers a simple means of selective surface hardening. [Induction hardening the end of a shaft, for example, or flame hardening the teeth of large gears.] Commonly a part will be heat treated and tempered to obtain a deep hardening characteristic, and then induction hardened to obtain high surface hardness. However, if the designer has a choice of carburizing and hardening, or induction hardening, and both appear to be equally suitable, carburizing is the AMF preferred process.

c. A combination of carburizing and induction hardening is often used. Note that the carburizing process is not a hardening process in itself; it only increases the carbon content at the surface of the steel. The hardening process follows carburizing.

3. In through hardening it becomes increasingly difficult to attain high tensile strengths as section size increases. Particular attention is directed to tables concerning depth of hardening and size of rounds listed in each material standard.

402.1.2 USE OF HARDENABILITY CURVES IN SELECTING AN ALLOY STEEL

1. Hardenability is the property of steel to "deep harden" at slow cooling rates (as

STANDARDS
AMERICAN MACHINE & FOUNDRY COMPANY

TENTATIVE

305.1 SPRINGS - GENERAL. Of the various types of springs, this standard will treat only helically wound, round wire springs. Three types are extension, compression and torsion springs.

305.1.1 In order to simplify the design of extension and compression springs and to bring about some measure of standardization, AMF has developed the charts presented on pages 305.2.4 - 305.2.7, and 305.4.4 - 305.4.8. These should prove adequate for the general run of springs encountered on automatic machinery. They will also prove helpful in arriving at the starting point in the design of springs for such critical applications as aircraft engine valve springs, for example, mentioned charts are not adequate.

305.1.2 The following data is also presented, for the design of those springs for which the above

1. Equations (1) & (2) are the two fundamental formulae upon which practically all round wire extension and compression spring calculations are based.
See 305.6 for torsion spring formulae.

$$f = \frac{8 D^3 P}{d^4 G} \quad \text{eq (1)} \qquad S = \frac{8 P D f}{\pi d^3} \quad \text{eq (2)}$$

where: f = deflection per coil in inches.
P = applied load in lbs.
D = mean diameter of spring in inches.
G = modulus of torsional rigidity in psi (see fig. 5).
d = diameter of wire in inches.
S = torsional stress in psi.
f = Bahl factor for wire curvature (see fig. 4).

2. Extension springs are customarily close wound with some "initial tension" wound into spring in order to obtain larger forces with smaller deflections and more compact springs. This effect is demonstrated by figures 1 & 2.

Deflection per coil as determined from formula (1).
Springs wound without initial tension, equal to the actual deflection.

f_0 = actual deflection per coil in spring with initial tension.
f_{t1} = theoretical deflection per coil that would be required to produce the stress wound into the spring as initial tension.
S_{t1} = stress due to initial tension.

Springs wound without initial tension start to deflect as soon as the load is applied (fig. 1).

Springs wound with initial tension do not start to deflect until an initial load has been applied (fig. 2). After deflection has started, both springs deflect at the same rate and reach the same stress at the same load.

STANDARDS
AMERICAN MACHINE & FOUNDRY COMPANY

100.0 Production Drawings - A complete set of drawings covering an article of equipment shall, in general, consist of the following:

100.0.1 Final Assembly drawing which will show:

100.0.1.1 A List of Parts as per 102.0* which will show:

100.0.1.1.1 The numbers of major assemblies that make up the Final Assembly but not the numbers of any details or minor assemblies making up those major assemblies.

100.0.1.1.2 Loose Parts - those detail, foreign, model or commercial parts which are not specified on any of the assemblies.

NOTE: Final Assemblies will not ordinarily indicate methods of assembling nor specify machining operations nor dimensions. However, where these cannot be done in any operation before reaching Final Assembly, these will be indicated.

100.0.1.2 All necessary Installation dimensions and notes whenever an installation drawing is not required.

100.0.2 Major or Minor Assemblies which will show:

100.0.2.1 A List of Parts the same as a Final Assembly.

100.0.2.2 All dimensions or notes necessary to make the assembly.

NOTE: Weldments are considered as minor assemblies and shall be treated as such with details of the separate parts made as in other assemblies.

100.0.3 Installation Drawings, if required, which will show groups of part and minor assemblies, not called out on any other major assemblies that are to be installed in the Final Assembly as components.

100.0.4 Detail Drawings

100.0.4.1 Detail drawings are made for each AMF designed compo part.

100.0.4.2 Commercial parts, a description of which would be t long for a few lines of the Parts List and List of will be detailed and given an AMF detail number.

- mercial parts that must be altered will be giv number.

ALIGNMENT

STANDARDS
AMERICAN MACHINE & FOUNDRY COMPANY

502.1 Element of Alignment - specifies the amount of allowable deviation from a datum line.

.XXX Dimension appearing on Ref. Dwg. No. 502.0.10 is the tolerance per linear inch, as reflected in tables 1,2, 3 & 4, of the Fabrication Quality desired by engineering.

Plane Surfaces - refers to 2 surfaces in a plane.

se surfaces must be
line within .XXX

FIG. 1

TABLE 1 - FABRICATION QUALITY

LINEAR INCH ← L →	STANDARD LIMITS Mill	Plane	GROUND	LAP
	✓	✓	✓	✓
	63	125	32	2
	125	250	63	4
	250	500	125	8
		1000	250	16
		2000		
	.XXX		.XXX	.XXX
0 to 1.0	.0020		.0010	.0005
to 2.0	.0025		.0015	.0010
to 3.0	.0030		.0020	.0015
to 5.0	.0040		.0025	.0020
to 10.0	.0050		.0035	.0030
to 20.0	.0100		.0050	.0040

TOLERANCE DELINEATION | Issued: 9-13-55 | Revised:

Two classes of standards are employed at American Machine and Foundry Co. Local standards, printed on white paper, are concerned with problems of exclusive interest to a specific operation or plant. Joint standards deal with issues of company-wide interest. They are approved, distributed and policed by the Joint Standards Committee; tentative standards are printed on salmon-colored paper, approved final standards on buff-colored paper.

Typical pages shown here were drawn from the AMF joint standards book. All joint standards are number-coded according to the following subject breakdown:

Subject	*Section*
Procedures	100
Drafting Room Practice	200
Design Information	300
Materials and Finishes	400
Shop Practice	500
Tables and Charts	600
Quality Control	700

mittee, and a summary of revisions or additions to external standards is presented to the joint committee for consideration. Frequently company standards are altered accordingly.

Development of a Standard

AMF recently released a tentative standard on springs. While developing this standard, a member of the Standards Department worked co-operatively with the head of the manufacturing research department of one of the plants. In compiling spring data, they reviewed many hundreds of spring drawings that had been made through the years. Wire size, material, spring index, outside diameter, inside diameter, type of spring, etc., were tabulated from the drawings.

Upon reviewing this information, they decided that the more commonly used wire sizes and spring indices could be standardized. Nomographs were prepared for the preferred spring indices, and each listed the preferred wire sizes. Various standards of societies and industry were reviewed and eight spring companies were consulted before the first rough draft was prepared.

The draft was reviewed by the joint committee and suggested revisions were discussed with the spring companies before being incorporated in the standard. Finally, a member of the Standards Department discussed the finished document with the engineering department of a well-known spring manufacturer before it was printed as a tentative standard.

The information to be shown on spring drawings was standardized and appliques were printed, listing only the information necessary to define a spring properly. Use of appliques assured that extraneous information would not be entered on drawings. The information that the shop has to work from is always similar and it is presented in the same orderly fashion.

Benefits of Program

It is rather difficult to determine savings directly attributable to a standards program. Usually, the benefits received from the use of technical standards are both tangible and intangible. Realization of the objectives of adequate standardization is a part of the net return. Some standards are essential for modern manufacturing operation while others promote efficiency in a more direct way. In any event, specific valuation is difficult and, presumably, must be based in each instance on an estimated comparison of costs with and without the standard.

Approximately five years ago, AMF formed their corporate Standards Department to co-ordinate standards on a company-wide basis and eliminate duplication of effort within the corporate family. Shortly after the department's organization, inventory was taken of its accomplishments.

Since no records of the dollar value realized through use of technical standards were known to exist, evaluation was based on opinion only. However, to illustrate the importance and magnitude of this subject, the following figures are offered as conservative estimates.

Drafting Practices: In the first year after adopting standards, one design section was able to reduce its drafting time from 5.2 to 4.3 hr per sq ft. It is estimated that at least half of this saving, or approximately 0.4 hr per sq ft, is due to standards. This 0.4 hr represents approximately 6000 hr per year or $33,000 saving.

The use of standards in the design stage allows for uniform interpretation of drawings by all concerned. Observation of the standard on decimal system of dimensioning in the design stage means that people in the shops no longer have to convert fractions to decimals. It is estimated that this factor alone cut scrap losses by $5000 per year.

The standard on drafting room practice (which provides for the replacement of delineation with description for simple parts such as pins, tie rods, studs, bearing retainers, shims, compression springs, spacers, washers, etc.) is saving a minimum of $2400 per year in drafting room *A*. It is estimated that another standard on simplified drafting room practice is saving up to 40 per cent of total design time, which in the case of drafting room *B* amounts to 33,000 hr, or approximately $165,000, per year.

The processing of drawing changes in engineering department *B* formerly cost an average of $30 per change. Total expenditure for this purpose was approximately $60,000 per year. It is estimated that the standard on this subject cut this time in half, with savings of $30,000 per year.

Design Specifications: Engineering standards that have a direct bearing on manufacturing costs are extremely important. Specifications for material, dimension tolerances, and machined surface finishes are three factors that affect manufacturing costs to a considerable degree.

Material costs represent a considerable sum of money and require the controlling influence of engineering standards. The specification of a material that is superior to its functional requirements increases the cost of material anywhere from 10 to 600 per cent. If a material is incorrectly specified once in 25 parts, thus increasing its cost by 20 per cent, the yearly increase in material costs at plant *C* will amount to $14,000.

Machining tolerances are an excellent field for cost control through education by engineering standards. A summary of relative costs of various commonly used tolerances indicates the possibilities for savings.

Tolerances (±in.)	Relative Cost
0.001	17
0.002	11
0.005	5
0.010	3
0.015	2
0.030	1

Practically all machining operations are dependent upon "tolerances." The improper specification of

tolerances can increase the cost of an operation up to 1700 per cent. From a conservative estimate based on one error in 200 specifications, the increased cost of manufacturing at plant *C* amounted to approximately $24,000 per year from this cause.

The standard on cylindrical fits is saving plant *D* up to $50,000 per year. The standard on tolerances including parallelism and squareness is saving this same plant approximately $6,000 per year for one manufactured item alone.

One manufacturing facility, plant *C*, is scheduling more than $12 million worth of machining per year. Machined surfaces consumed roughly two-thirds of the total fabrication time required for producing an average part. That means approximately $8 million worth of machining time depends upon surface finish specifications. Calling out a finish that is finer than absolutely required can increase the cost of the machining operation anywhere from 28 to 370 per cent. Obviously, proper guidance through a standard on surface finishes is required under the circumstances. Were an error to occur only once in every 100 surface specifications, the yearly increase in manufacturing costs would be $22,400.

It is estimated that another facility, plant *D*, had been spending in excess of $10,000 per year producing better finishes than those functionally required before the standard was put into use.

The standard specifies machine surface finishes in rms (root-mean-square value of roughness) microinches to provide for greater control over surface-finish requirements. The differences in cost of a few of the more commonly used finishes illustrate savings possibilities.

Roughness (mu in., rms)	Relative Cost
16	3.7
63	2.3
125	1.8
500	1.0

Part Standardization: The use of standard parts offers a fertile area for cost reduction. One of the important considerations in standardizing is the advantage of buying or manufacturing in large quantities. By standardizing sprockets, for example, the number of types produced at one facility was reduced, with an attendant increase in the number of each type. The following tabulation provides a comparison of unit costs for varying quantities of two sprockets.

Quantity	Sprocket *A*	Sprocket *B*
5	$9.65	$6.75
25	5.09	3.29
50	4.60	2.93
100	4.35	2.75

Purchasing or manufacturing in lots of 100 rather than 5 represents a reduction in cost of 57 per cent. The difference between lots of 25 and 50 represents a 15 per cent reduction in cost. The yearly reduction in cost for plant *C*, considering that 60 per cent of its sprocket production fell into standard parts, was approximately $4400. In addition, savings in capital invested as well as storage space were realized.

Standardization of commercial parts has allowed AMF to (1) mass-produce standard manufactured parts for stock in large quantities, (2) permit company-wide utilization of costly patterns and dies, (3) reduce engineering hours required for delineation of standard manufactured parts, and (4) procure commercial parts under a consolidated program which permits company-wide volume purchasing.

The End Result

Experience at AMF has shown that acceptance of standards is slow in pace and is often hampered by misinterpretations, personalities, and just plain resistance to change. Some of these obstacles have been overcome, and others are gradually disappearing. But the overall results have been extremely successful and the program is gaining enthusiastic endorsement and co-operation from the management of all divisions and departments.

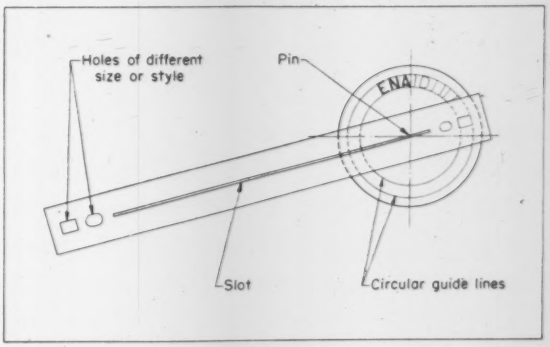
Extensive re-education programs are in effect to sell standards where none are in use. As acceptance increases, wider co-operation develops between divisions. This co-operation results in vast savings by distributing work loads, both engineering and manufacturing, over several different divisions.

Based on AMF's experience, flexible, adaptable standards, voluntarily adopted by divisions and subsidiaries, can serve a large and diversified organization well—and profitably. However, size should be no limit. The same should hold true for any engineering-manufacturing organization, regardless of scale of operation.

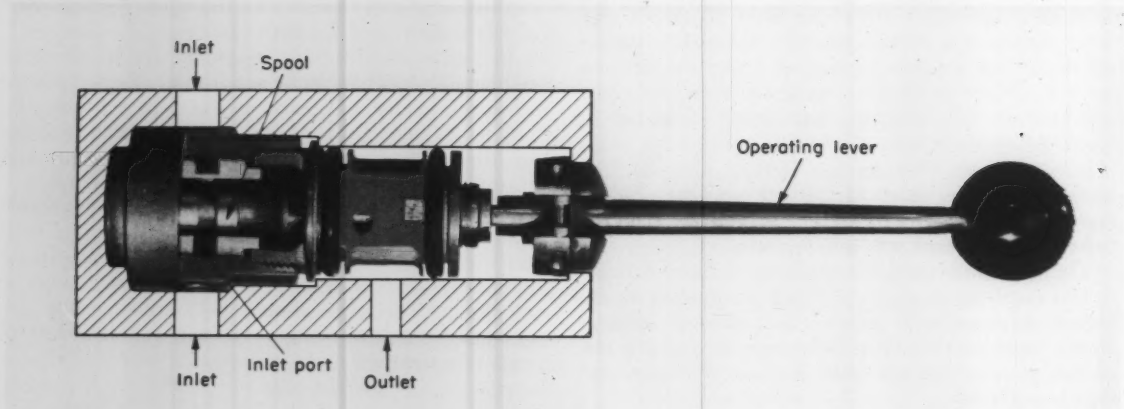
Tips and Techniques

Lettering Guide

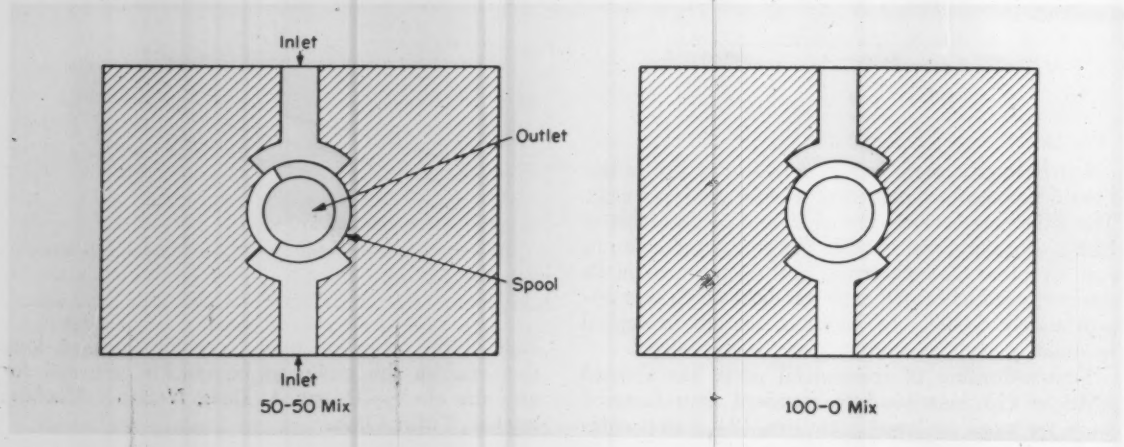
A simple guide to aid lettering around a circle can be made from a strip of plastic. The edges of square, round, oval, or rectangular holes, cut in the ends of the strip, are used for guide lines. A long slot enables the guide to be quickly adjusted for any size circle.—Harry A. Dom, *National Machinery Co., Tiffin, Ohio.*

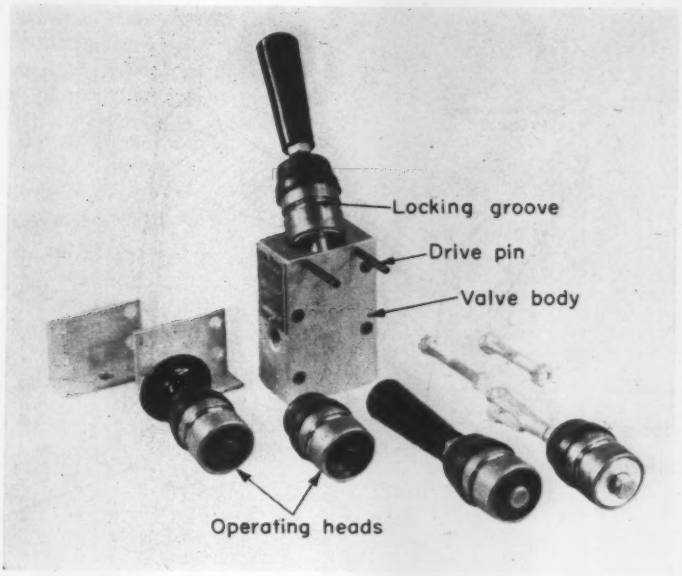


scanning the field for *ideas*



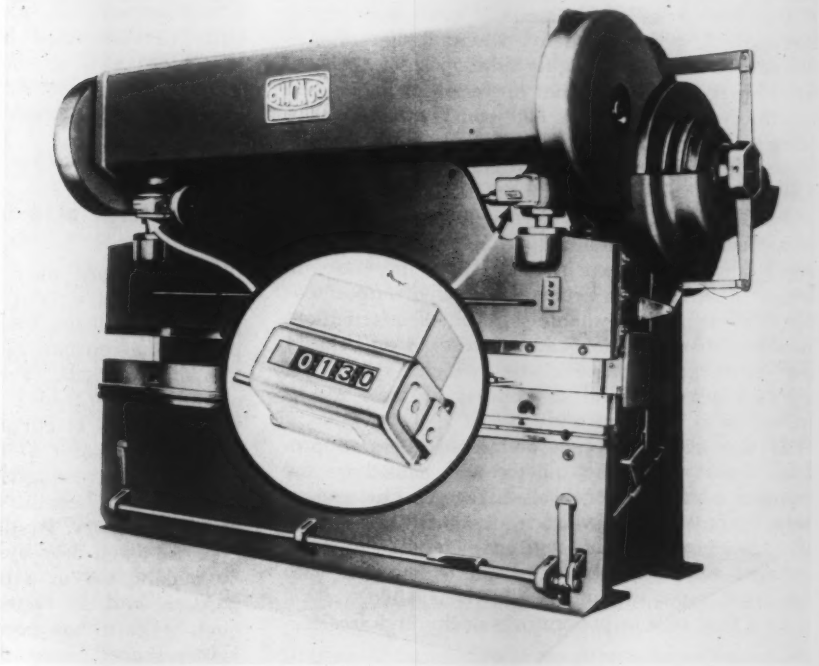
Single-lever control of two functions—fluid blending and flow control—is achieved in a mixing-valve design by a spool that both rotates and slides axially. The tubular spool has a cutout portion around slightly more than one-half the periphery. In the full-volume and 50-50 mix position, the cutout section uncovers both inlet ports, which are located on opposite sides of the housing. Rotation of the spool progressively covers one of the inlet ports, varying fluid-mix proportions from 50-50 to 100-0. Output-flow rate is controlled by axial movement of the spool, closing off both inlet ports equally. The design was developed by Moen Faucet Co





Interchangeable-head design for valve unit facilitates variation of actuation device to meet space and operating requirements. Developed by Hanna Engineering Works for a pilot-valve, the design permits selection and use of any of a number of operating heads on a single valve body. When the head is in place, it is retained by two drive pins in holes in the valve body, which engage a circumferential groove on the stem of the head. Heads can be readily removed and changed by driving out the two pins.

Measurement of linear movement in power-screw applications is provided by a conventional mechanical counter. The power-screw assembly consists of a motor-driven rotating nut and a nonrotating screw which moves axially. The drive nut is also connected directly to the counter, which indicates the revolutions of the nut. Accurate repeatability of adjustment is possible by recording the counter reading for any desired position of the screw. In a special counter developed by Durant Mfg. Co., the readout is directly in 0.001 in. of lineal movement of the screw.



LINKAGES *VS.* CAMS

. . . a quantitative comparison for rise-dwell-drop-dwell applications

By THOMAS P. GOODMAN
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Cambridge, Mass.

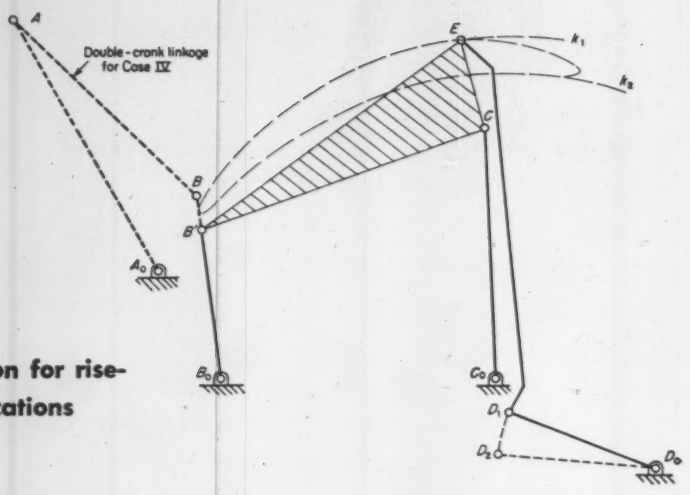


Fig. 1—Case I linkage (solid lines) for rise-dwell-drop-dwell motion. A variation, Case IV, employing a double-crank linkage in series, is also shown

SINCE a machine motion, such as the rise-dwell-drop-dwell motion required to open and close a valve, can often be obtained from either a cam or a link mechanism, the relative advantages of the two types of mechanisms have been much discussed.[1,2,3,4] In Germany, where design of mechanical linkages is a highly developed science, one often hears the opinion that operation of high-speed machinery (above about 800 rpm) can be made quieter and smoother by replacing cams by link mechanisms designed to give approximately the same output motion. Indeed, one of the main goals in the study of mechanisms in Germany has been to develop methods for designing linkages for this purpose. There is an extensive body of literature on design of linkages to produce a desired output motion.[3,4,5] In the available published information, however, there are no quantitative data on velocity and acceleration characteristics which explain the reported quietness and smoothness of these mechanisms in comparison with cams.

As the science of cam design advances to produce cams which are quieter and smoother, the reported advantages of dwell linkages in this respect may become less significant. If quantitative data on velocity and acceleration characteristics of dwell linkages were available, a direct comparison with the latest types of cams would be possible.

As a first step in presenting velocity and acceleration data on dwell linkages, this article gives the results of a case study of some specific designs of "dwell linkages" which have an oscillatory rise-dwell-drop-dwell output motion when input motion is uniform rotation. Output velocities and accelerations (as computed from graphical layouts) are shown, as well as output displacement diagrams, to permit a comparison with cam mechanisms which have similar displacement diagrams.

[1]References are tabulated at end of article.

Basic Design of a Dwell Linkage

The standard method of achieving a dwell in the motion of an output link is to make use of a point on a linkage, such as point E in Fig. 1, whose path has a constant radius of curvature over a portion of its length. This point is then connected to output link DD_0 by link ED whose length is equal to this radius of curvature. The output link is so located that point D is at the center of curvature while E is traversing the constant-curvature portion of its path. Then the output link "dwells," i.e., remains stationary, for this portion of the travel of E.

A rise-dwell-drop-dwell output motion is achieved by making use of a point E whose path has two portions with the same constant radius of curvature. Such a path has been described by Rauh[3] as a kidney-shaped curve. In Fig. 1, D_1 is at the center

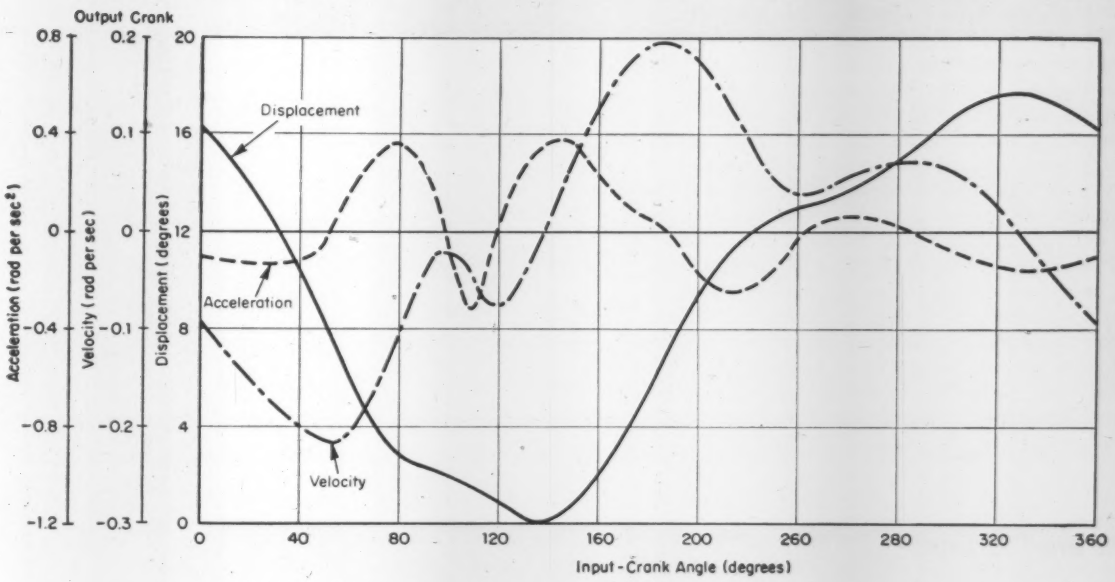


Fig. 2—Output motion of Case I dwell linkage

of arc k_1 and D_2 is at the center of arc k_2. As E moves along arc k_1, D dwells at D_1; as E moves from k_1 to k_2, D drops from D_1 to D_2; as E moves along k_2, D dwells at D_2; and as E moves back to k_1, D rises from D_2 back to D_1. Hence, output link DD_0 has a motion similar to that of a pivoted cam follower. Angular travel of the output link during the rise and the drop can be increased or decreased merely by changing the distance of pivot D_0 from centers of curvature D_1 and D_2.

The main problem in designing a dwell linkage is to find a point E having a path with suitable curvatures. In Fig. 1, E is a point on the connecting rod of a four-bar linkage; the so-called coupler curves described by such points offer a wide range of possibilities.[2,3,4] Hain[4] shows how linkages having suitable coupler curves can be found by the method of "point-position reduction." Hrones and Nelson[2] have compiled an atlas of coupler curves from which a suitable curve can be selected. Rauh[3] discusses extensively proportions of linkages and location of coupler curves to give one, two, three, or even four dwells in the output motion.

The dwell achieved by a linkage designed in this way can be only approximate, since the radius of curvature of a coupler curve is only approximately constant over any finite length of the curve. However, the approximation to an exact dwell is close enough for many practical applications. When output motion is investigated by means of graphical layout, inexactness of dwell motion shows up much more clearly in output velocity and acceleration curves than in the output displacement curve itself.

One limitation of dwell linkages based on coupler curves of a four-bar linkage is that the longest dwell which can be achieved is approximately 90 deg of rotation of the input crank ($B'B_0$ in Fig. 1). If there is a dwell at each end of the output motion, as in Fig. 1, the upper dwell can be about 90 deg of input rotation, but maximum duration of the lower dwell can be only about 30 deg. This is because arc k_2 of the coupler curve is traversed by point E during a much smaller input angle than is arc k_1. To achieve a dwell of longer duration, Hain[6] has shown that the four-bar linkage can be driven by a double-crank linkage (A_0ABB_0, indicated by dashed lines in Fig. 1), so that crank $B'B_0$ has nonuniform rotation, moving more slowly during a dwell in the output motion and more rapidly during the remainder of the cycle.

Since in all usual cases a coupler curve is a smooth, continuous curve, it follows that in a dwell linkage, when the motion of input crank $B'B_0$ is smooth and continuous, output-crank motion is also smooth and continuous (assuming negligible backlash in the linkage). Therefore, not only velocity and acceleration but all higher derivatives of the output motion are finite and continuous. In particular, the "pulse," or first derivative of acceleration, is always finite. Since recent studies of cam dy-

namics[7] have shown that a finite value of pulse is a most important requirement for quiet, smooth operation of cam-driven systems, this property of dwell linkages is an explanation of their reported quietness and smoothness.

From studies of cam-driven systems, it is known that when higher derivatives of the output displacement are made finite and continuous at the beginning and end of a rise or drop, maximum velocity and maximum acceleration during the rise or drop become higher than they would be if the higher derivatives were not all finite. It is also known that a displacement curve which is asymmetrical during a rise or drop motion has higher maximum velocity and acceleration than a symmetrical curve. It might therefore be suspected that dwell linkages have higher output velocities and accelerations than cam followers designed for similar output motions. To investigate these effects in a few specific cases is the object of the case studies described here.

Simple Dwell Linkages

The linkage considered as Case I is the dwell linkage shown by the solid lines in Fig. 1. Dimensions of this linkage were supplied by Hain.[6] It is intended to be illustrative of an "ordinary" rise-dwell-drop-dwell linkage, i.e., one designed primarily to illustrate the principle of dwell linkages, without special consideration of velocity and acceleration characteristics of the output motion.

Angular displacement, velocity, and acceleration of output crank DD_0 for uniform rotation of input crank $B'B_0$ are shown in Fig. 2. In these curves, as in all others in this article, constant angular velocity of the input crank is taken as 1 rad per sec (9.55 rpm), and the position shown in the drawing of the linkage is the origin (0 deg) of the horizontal scale.

Output motion curves for any other input angular velocity, denoted by ω rad per sec, may be obtained by multiplying output velocity by ω, and output acceleration by ω^2. Clockwise rotations are considered positive. The linear scale of Fig. 1 does not affect the curves of Fig. 2, which are all in terms of angular motion.

From the displacement diagram, it is seen that the upper dwell is of longer duration than the lower dwell, but that both are relatively short. Also, rise and drop motions are irregular. Toward the end of both the upward stroke and the downward stroke, the output crank slows down and then speeds up again. This feature of the motion may be just what is needed in some applications. However, as is evident from the acceleration curves, it results in a higher maximum value of acceleration than there would be if the motion were more regular. Since the acceleration curve has no discontinuities or abrupt changes in slope, however, the pulse is finite and continuous. The output motion, like that of the other dwell linkages to be discussed, is therefore expected to be smooth and quiet.

To achieve a more regular rise and drop motion,

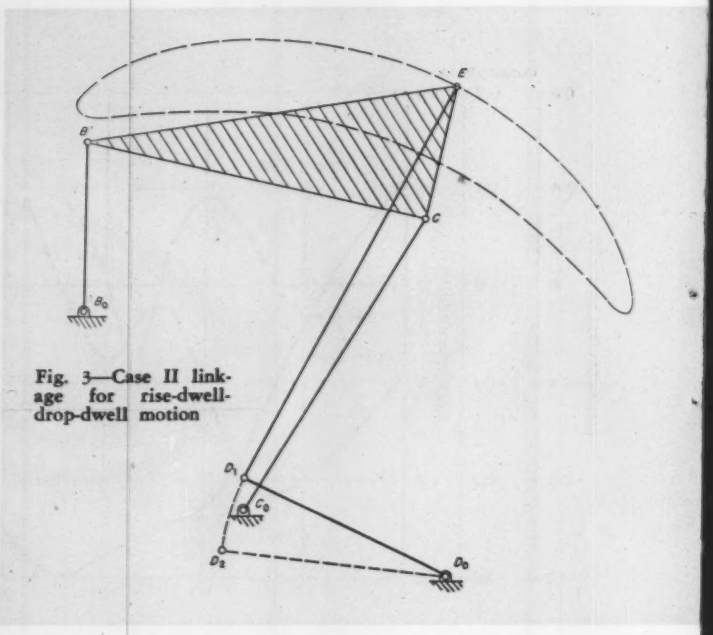
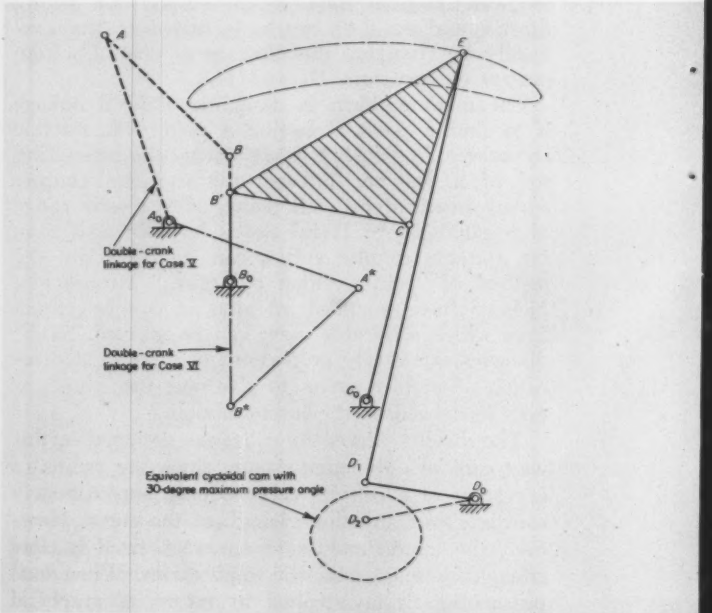


Fig. 3—Case II linkage for rise-dwell-drop-dwell motion

linkage of Case II (Fig. 3 and 4) was designed with the aid of the linkage atlas of Hrones and Nelson.[2] From the more than 7000 coupler curves in the atlas, a kidney-shaped curve was selected which was as nearly symmetrical as possible and had the longest possible sections of constant curvature with a reasonable distance between the two sections. Dimensions of the linkage were taken from the atlas. Points D_1 and D_2 were located at the centers of curvature of the two constant-curvature portions of the coupler curve. Pivot point D_0 was then lo-



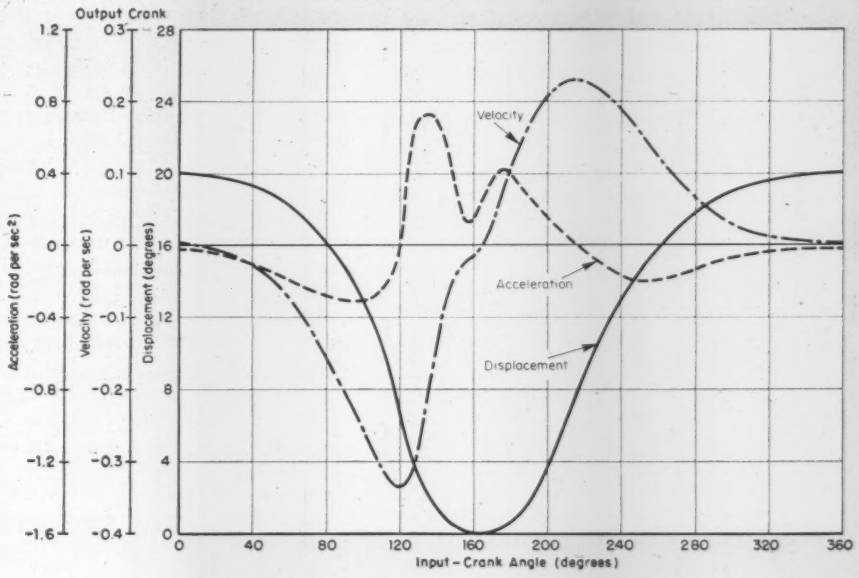


Fig. 4—Output motion of Case II dwell linkage

cated to give a rise and drop of 20 deg in the motion of the output link.

From Fig. 4 it is seen that the lower dwell is quite short and that the output displacement curve is not actually symmetrical, since the rise period is shorter than the drop period. This asymmetry shows up more clearly in the velocity and the acceleration curves than in the displacement curve, and makes maximum acceleration during the rise nearly twice as great as during the drop. This coupler curve was obtained by interpolation between two coupler curves shown in the atlas. Better results could undoubtedly be obtained by further interpolation or by using points outside the region covered in the atlas, but the objective in this example was to see how good an output-motion curve could be obtained by a relatively short search through the atlas.

To find a more symmetrical coupler curve, the investigations of Rauh[3] were consulted. Rauh found that the most useful kidney-shaped curves are obtained when the proportions of the links, $(B'B_0)$:

Fig. 5 — Left — Case III linkage (solid lines) for symmetrical rise-dwell-drop-dwell motion. Also shown are two variations, Cases V and VI, with double-crank linkages in series. The cycloidal cam is the approximate equivalent of the Case III linkage

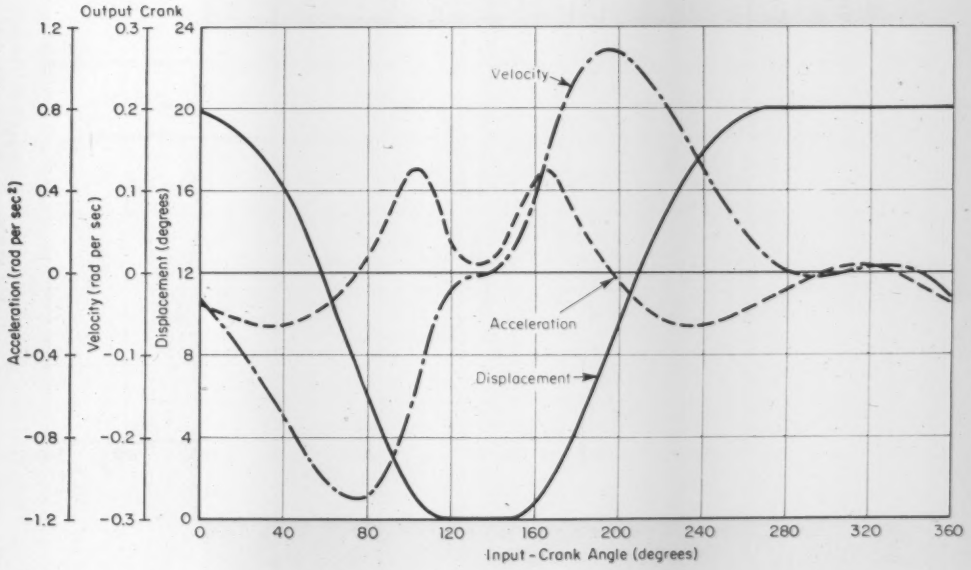


Fig. 6—Output motion of Case III linkage

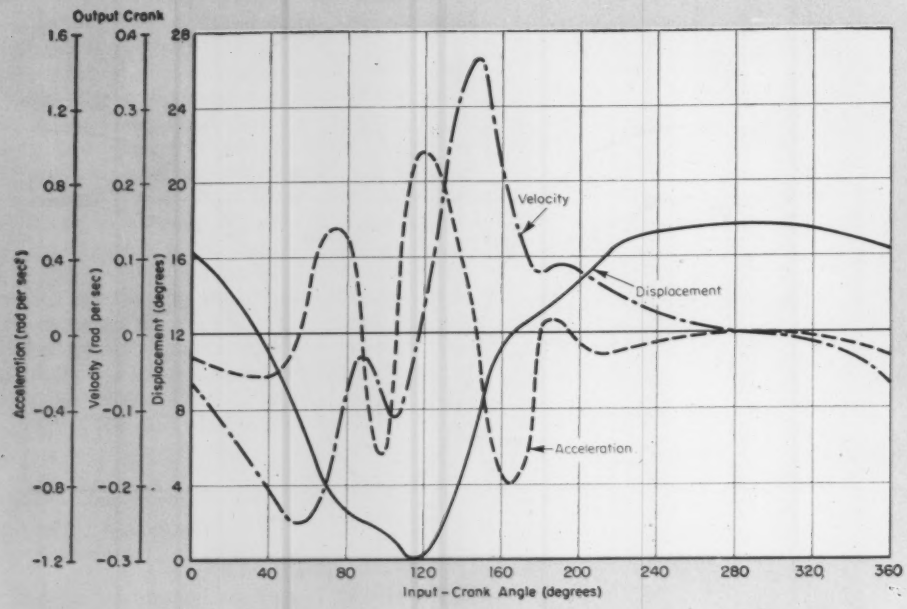


Fig. 7 — Output motion of Case IV linkage shown in Fig. 1

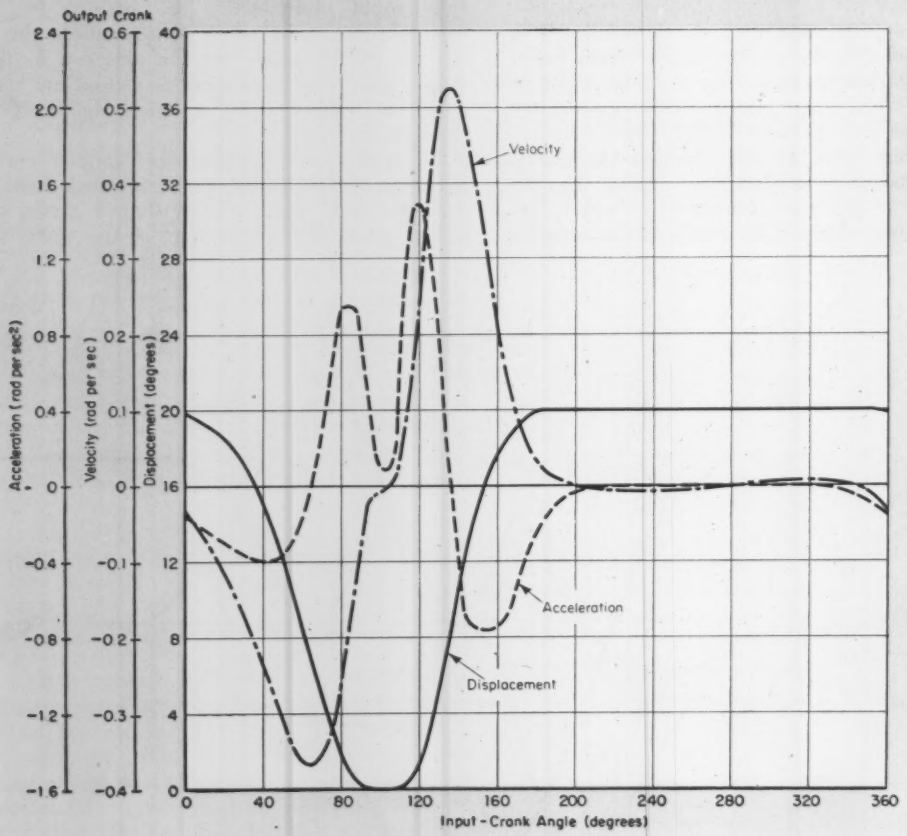


Fig. 8 — Output motion of Case V linkage shown as one of the variations in Fig. 5

$(B'C)$: (CC_0): (B_0C_0), are in the neighborhood of 0.5: 1.0: 1.0: 1.0. Link proportions for both Case I and Case II are in this region. Rauh found empirically that when link proportions are exactly 0.5: 1.0: 1.0: 1.0, points E having the most suitable coupler curves for rise-dwell-drop-dwell linkages lie approximately on a straight line through C making an angle of 96 deg with $B'C$.

If E coincides with C, the coupler curve consists of two perfect circular arcs—the path of C as it swings around C_0—but since the distance between the centers of curvature of the two arcs is zero, this curve cannot produce a rise and drop in the output motion. As E moves farther away from C, sections of the coupler curve with nearly constant curvature become shorter, but the two centers of curvature move farther apart, giving useful coupler curves for a rise-dwell-drop-dwell motion.

Hrones and Nelson found that a symmetrical coupler curve can be obtained by making $(B'C) = (CE) = (CC_0)$. Combining these conditions, a symmetrical coupler curve which is nearly optimum for a rise-dwell-drop-dwell linkage can be obtained by making $(B'C) = (CE) = (CC_0) = (B_0C_0) = 2\ (B'B_0)$ and angle $B'CE = 96$ deg. These are the proportions used for Case III, the linkage shown by the solid lines of Fig. 5. Its output motion curves are shown in Fig. 6.

Due to the symmetry of the coupler curve, the output displacement curve is now also symmetrical, with rise and drop motions of approximately equal duration. But the output velocity curve is asymmetrical during the rise and during the drop, resulting in a peak positive acceleration about twice as great as the peak negative acceleration. Peak accelerations could be reduced if velocity curves during rise and drop could be made symmetrical, which would make peak positive and negative accelerations equal.

Dwells in Case III are considerably longer than in Cases I and II, but the linkage of Case III requires much more space for a given total travel (D_1D_2) of the output crank.

Dwell Linkage in Series with Double-Crank Linkage

To increase the duration of one of the dwell motions, any of the linkages so far discussed can be connected in series with a double-crank linkage, as explained by Hain.[6] Case IV, Fig. 1 and 7, is a combination of a double-crank linkage and the dwell linkage of Case I, in which the double-crank linkage was designed by Hain to give the longest dwell period consistent with a reasonable transmission angle in the double-crank linkage.

In comparison with Fig. 2, Fig. 8 shows higher peak velocities and accelerations, since the nondwell portion of the cycle is completed more rapidly. Otherwise the two sets of velocity and acceleration curves are much the same. In both cases, irregularities in the displacement curves result in high peak accelerations.

Cases V and VI, Fig. 3, 8, and 9, are combinations

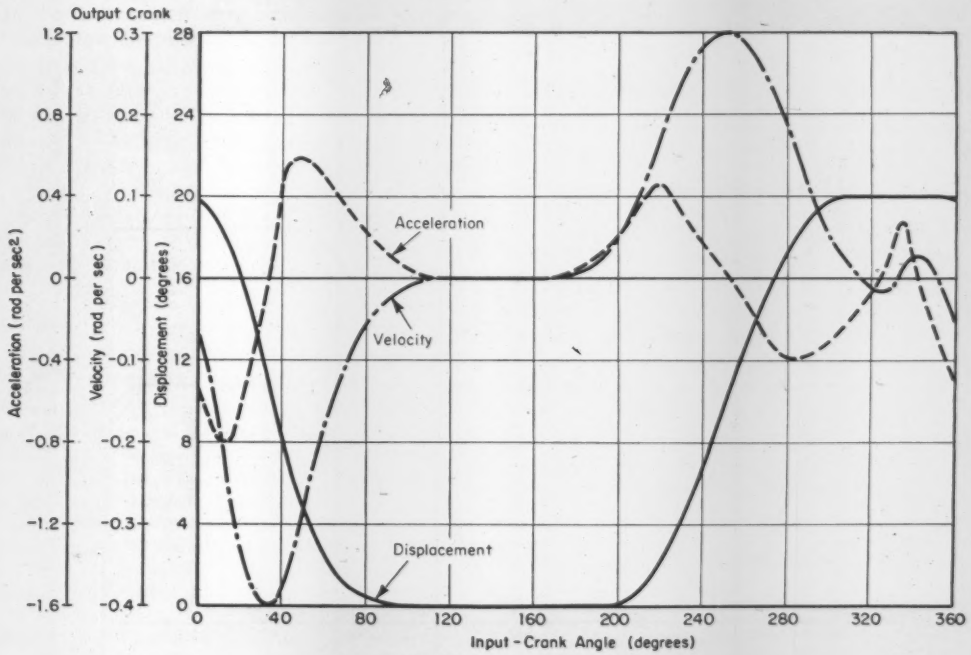


Fig. 9—Output motion of Case VI linkage shown in Fig. 5

of the dwell linkage of Case III with the same double-crank linkage used in Case IV. The double-crank linkage is arranged in Case V to increase the duration of the upper dwell, and in Case VI to increase the duration of the lower dwell while decreasing the duration of the upper dwell. In both cases peak velocities and accelerations are higher, as expected, than in Case III. The double-crank linkage also introduces a small amount of asymmetry into the output displacement curve. Symmetry could be preserved, however, by using a double-crank linkage with a slider in place of the connecting rod.

By suitable design of a double-crank linkage, as explained by Hain,[6] durations of dwell periods can be varied at will, subject to the limitation that when one dwell is increased, the other is decreased. To increase the durations of *both* dwells, while shortening periods of rise and drop, a more complex linkage is necessary.

Comparison with Cam Mechanisms

Recent investigations of cam dynamics[7] indicate that quiet, smooth operation is to be expected from an accurately machined cam in which the pulse, or first derivative of acceleration, in the follower motion remains finite. Since the best-known follower motion satisfying this condition is the so-called cycloidal motion, this motion was selected for comparison with the output motion curves of dwell linkages.

The output-displacement curves for Cases III, V, and VI were matched as closely as possible with cycloidal follower-displacement curves. The follower-motion curve corresponding to Case III is shown in Fig. 10, and the curves corresponding to Cases V and VI are similar in appearance, except that the shorter rise and dwell periods result in higher velocities and accelerations.

In matching follower displacement curves with linkage output curves, durations of the dwells and their location in the cycle were made approximately equal, but shapes of the rise and drop portions of the curves are, of course, not the same. Two displacement curves which agreed exactly at every point would also have identical velocity and acceleration curves. Since a cycloidal curve has only a small displacement during the initial and final portions of the rise and drop motions, these portions of the cam-follower curves give about as good an approximation to a dwell as the corresponding portions of the linkage output curves.

From a comparison of Fig. 6 and 10, it is seen that maximum velocity of the cam follower is slightly less than that of the linkage output, while maximum acceleration of the cam follower is about 2/3 that of the linkage output. The same relationships are found to hold for Cases V and VI, since maximum follower velocities for the cams corresponding to these cases are 0.45 rad per sec and 0.35 rad per sec, respectively, and maximum accelerations are 0.93 rad per sec^2 and 0.55 rad per sec^2, respectively.

The lower maximum acceleration of the cam-follower motion can be explained on the basis that the velocity curves for the rise and drop motions are both symmetrical and the second and higher derivatives of acceleration are not kept finite. The pulse is finite but is not continuous at the beginning and end of rise and drop; thus the first derivative of pulse, or second derivative of acceleration, has discontinuities at these points. It is doubtful whether increased smoothness of operation would result from

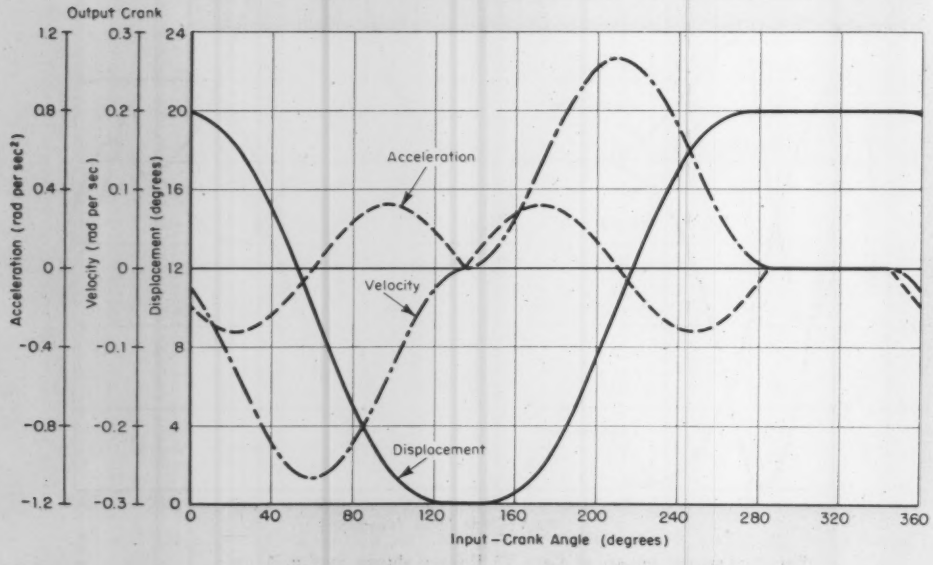


Fig. 10—Follower motion of cycloidal cam shown in Fig. 5 in relation to Case III linkage

making the pulse continuous[7], but this could be done by using the so-called 4-5-6-7 polynomial cam profile instead of the cycloidal profile, which would increase the maximum acceleration by about 15 per cent. This would still be substantially lower than the maximum acceleration of the cam follower. On the other hand, use of the modified-trapezoidal acceleration profile in place of the cycloidal profile would reduce the maximum acceleration by about 20 per cent, with the pulse remaining finite but not continuous.

Size of a cam for a given output motion is, of course, dependent on the allowable pressure angle. For a 30-deg maximum pressure angle, details of a cycloidal cam for the motion of Case III, Fig. 10, are shown in dashed lines in Fig. 5. In this case the cam is very much smaller than the corresponding linkage. For Cases V and VI, the cams would be slightly larger for the same maximum pressure angle because of greater maximum velocities, but the linkages would also be larger because of the addition of the double-crank linkage.

As noted earlier, the linkage of Fig. 5 is larger for a given output travel than are the linkages of Fig. 1 and 3. Even allowing for this difference, however, the dwell linkages turn out to be much larger than the cams.

Summary

This discussion may be summed up by saying that while dwell linkages are probably much better dynamically than poorly made cams, accurately machined cycloidal cams should exhibit nearly the same quietness and smoothness of operation as dwell linkages. In addition, cams can be designed to have lower maximum output accelerations which result in lower inertia forces. Also, in the cases considered, cams have been found to be very much smaller than dwell linkages. Since for a given rpm inertia forces are proportional to the sizes of the links, these forces might be much greater at high speeds in the dwell linkages than in the cams.

To keep these factors in proper perspective, however, the advantages of dwell linkages must also be kept in mind. Although more difficult to design for a desired output motion, dwell linkages are usually cheaper and easier to manufacture, since the principal operation required is the machining of holes. Also, a small error in locating a hole does not spoil dynamic performance of a dwell linkage, since output motion will still be smooth and continuous. By contrast, it is well known that a small bump on a cam profile can cause severe vibration. Finally, it is reported[4] that dwell linkages with their cylindrical bearing surfaces are less subject to wear than are cams and followers with their surface contact, although it is also stated[7] that cams with good dynamic properties are less subject to wear than are those with less favorable dynamics.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN.

Transactions containing the 13 papers (104 pages) presented at the Conference are available at $2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio. (or see Page 204).

The Fifth Conference on Mechanisms will be held at Purdue University, Lafayette, Ind., October 13 and 14, 1958.

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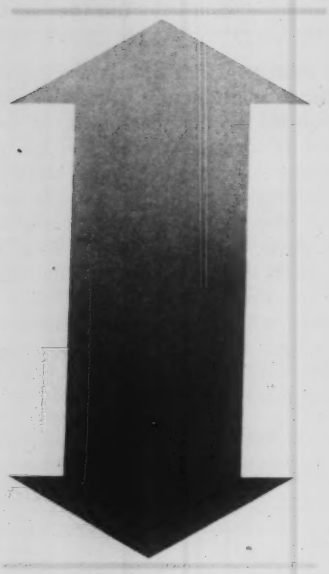
Tips and Techniques

Checking Tip

When a number of prints are to be marked with identical information not desired as a tracing change, checking can be simplified by this method. Instead of copying and checking each print from a "master copy," mark each print from the one just previously marked. Then check the last very carefully with the first. If they agree, it is practically certain that all intervening copies are correct. If they do not agree, and all copies have been kept in order, the point of error can be quickly found.—JESSE G. MCCUNE, *Kansas City, Mo.*

Extended Compass

For radii just beyond the reach of a standard compass, a length of lead, reinforced by metal sleeves found at the end of some drawing leads, can provide a sturdy extension. — ERNEST A. KREMEYER, *Anderson Bros. Mfg. Co., Rockford, Ill.*



Thermal Stresses in

Part 4 — Causes of Fatigue in Ductile Materials

By S. S. MANSON
Chief, Materials and Structures Div.
Lewis Flight Propulsion Laboratory, NACA
Cleveland, Ohio

PRESENCE of certain factors influencing the failure of ductile materials through thermal-stress fatigue was discussed in a previous article.[2] Degree and magnitude of these factors play decisive roles in the complete analysis of thermal-stress fatigue. Several of these quantitative aspects are considered in this article of the current series.

Temperature Variations

Even if a simple relation exists between plastic strain and number of cycles to failure in thermal-stress fatigue, the problem is complicated in practical cases by the interrelation of elastic and plastic strains. For example, assume that a completely constrained specimen is subjected to a given cyclic-temperature range (constant difference) of differing mean temperature. Different proportions of the total thermal strain of constraint are absorbed in elastic and plastic strains.

In addition, if the mean temperature is increased sufficiently, for a fixed temperature range, the maximum temperature will increase, thereby altering the temperature-dependent metallurgical effects. Finally, as the maximum temperature increases, more and more of the strain will tend to become localized in the hot regions.[3] Usually temperature tends to be nonuniform and yield points fall rapidly beyond certain temperatures.

Effect of maximum temperature on number of cycles to failure with the minimum temperature maintained constant is shown in Fig. 23.[4] Minimum temperature was maintained at 200 F while the maximum temperature was increased on the test specimens of high-temperature alloys, S-816 and Inconel 550. In the low range of temperature, small changes in maximum temperature drastically affected the life, but for S-816, maximum cycle temperatures above 1450 F produced very little effect on the life. This behavior reflects the metallurgical effects in S-816 at high temperature, Fig. 24. Here the increase in hardness during the thermal-stress fatigue test is plotted as a function of maximum cycle temperature. At all temperatures up to 1600 F, strain hardening was evident during the course of the test, but beyond a maximum temperature of 1450 F, the increase in hardness became less as temperature increased. Above this temperature the rate of loss of life is decreased, probably because of overaging which increases ductility. For Inconel 550, no such beneficial aging effects occurred in the temperature range from 1400 to 1600 F, and life fell off drastically as the temperature increased over the entire range of temperature investigated.

Clauss and Freeman[5] have attempted to present a strong case for the greater importance of maximum temperature over that of strain, Fig. 25. Here the number of cycles to failure is plotted against the maximum temperature of the cycle for cases in which the temperature range was kept constant. If the plastic strain per cycle were governed only by the temperature range, and if the number of cycles to failure were governed only by plastic strain per cycle, the plots would obviously be vertical lines. The large range of fatigue lives covered by both curves was intepreted to indicate that maximum temperature is of greater influence than strain per cycle.

[3]References are tabulated at end of article

Design

- *Temperature Variations*
- *Hold Time*
- *Sign of Strain*
- *Degree of Constraint*

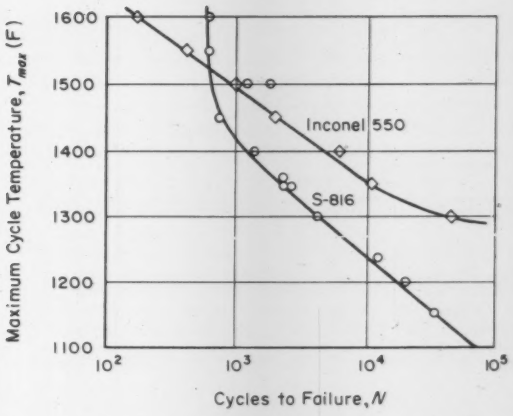


Fig. 23—Cycles to failure for two high-temperature alloys subjected to various maximum cycle temperatures. Minimum temperature was maintained at 200F

While the higher temperatures undoubtedly introduced metallurgical effects, it is also possible, however, that some of their effect was introduced through the increase in plastic strain per cycle by the strain-localization mechanism. It was evident that strain localization occurred because of the localized bulging which became more exaggerated as the maximum temperature of the cycle was increased. Bulging is one of the instability phenomena associated with thermal stresses, and will be more thoroughly discussed in a later section.

To illustrate the effect of mean temperature for type 347 stainless steel, Fig. 26, the temperature range was maintained constant but the mean and maximum temperatures were varied.[6] The number of cycles to failure decreased appreciably as the mean temperature increased.

Hold Time

The rate at which the temperature is changed and the amount of time the specimen is held at the high temperature can significantly affect the number of cycles to failure. If the specimen is held at the high temperature for a longer time, creep effects can occur as well as time-dependent metallurgical effects.

Coffin[6] ran several tests in which the hold time at the elevated temperature was varied for type 347 stainless steel. Hold times of 6, 18, 60, and 180 seconds were used. For experimental purposes, these hold times represented the limit of practical time to achieve test results. However, in practice much longer hold times, with attendant metallurgical effects, must be considered. It is seen, Fig. 27, that as the hold time is increased, the number of cycles to failure decreases. However, the data show considerable scatter, and complete interpretation is difficult because of the many factors that are affected by the increased hold time.

Clauss and Freeman[5] also determined the effect of hold time at an elevated temperature on S-816. Tests were conducted with hold times of 15 and 60 seconds at each of a number of maximum temperatures. Increased hold times, Fig. 28, can either increase or decrease the number of cycles to failure, depending on the maximum temperature. For S-816, in which overaging becomes an important phenomenon at high temperature, the life actually in-

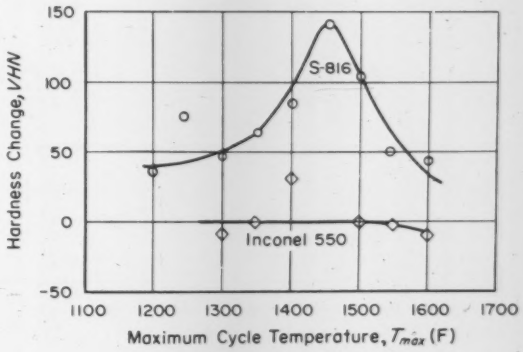


Fig. 24—Maximum cycle-temperature effect on hardness change of Inconel 550 and S-816 alloys during thermal-stress fatigue

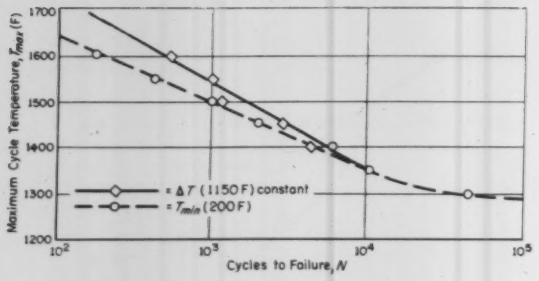


Fig. 25—Comparison of constant change in temperature and constant minimum-temperature cycling on fatigue life of specimens. Cycles were comprised of 30-second heating and cooling periods with 15-second hold period at maximum temperature

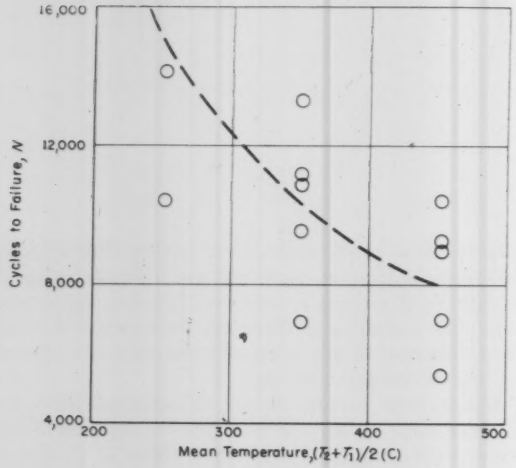


Fig. 26—Mean cycle-temperature effect on cycles to failure. Temperature range was constant at 300C

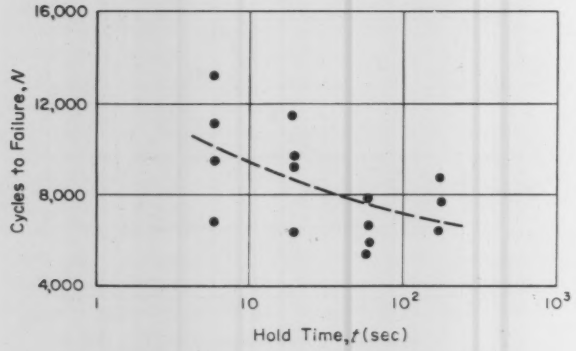


Fig. 27—Hold-time effect on type 347 stainless steel cycled between 200 and 500C

creased with higher hold times at the elevated temperature. At the lower temperatures, the opposite was true for increased hold times. Obviously the individual metallurgy of the material governs behavior to a considerable extent.

Creep effects associated with hold times may become highly localized if large temperatures are involved for reasons previously described. Thus the consequences of hold time can become very pronounced in such cases.

Sign of Strain

In the thermal-stress cycling model,[3] the specimen was assumed to be clamped for the first time when the specimen was at the elevated temperature. Thus in the first cycle, the specimen was stress-free when hot, and subjected to the maximum tensile stress when cold. However, further cycling resulted in a condition of compression when hot and tension when cold. In a similar manner, a specimen first clamped when cold would, in the first cycle, be stress-free when cold and in compression when heated. Successive cycling would result in compression when hot and tension when cold. Thus it might be expected that little difference would result when the specimen is clamped either hot or cold. This was indeed found to be the case by Coffin.[6] In fact, he found[4] that it did not matter whether it was tension or compression that occurred at the elevated temperature. In the latter series of tests, a specimen, instead of being constrained between two fixed ends, was installed in a cam-driven mechanism, so that it could be mechanically stretched when hot and compressed when cold. In this way, it was possible to induce, at any temperature, exactly the same mechanical strain as a constrained specimen, except that the strain was of the opposite sign. The number of cycles to failure by this method, Fig. 29, was nearly independent of the sign of the mechanical strain. Data showed considerable scatter, which was explained by dif-

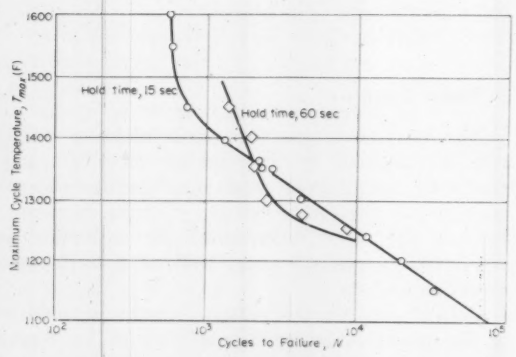


Fig. 28—Effect of time at maximum cycle temperature on fatigue life of high-temperature alloy S-816

ficulties in maintaining proper phase relation between temperature variation and cam motion. Therefore, the conclusion regarding independence of life on sign of strain must be regarded as tentative.

Degree of Constraint

In most of the tests conducted to date, the temperature-cycled specimen has been more or less completely constrained at its ends, representing an extreme case. In practice conditions of partial constraint range to complete freedom of expansion. Thus, Chiswick[1] found an important thermal-cycling effect on alpha uranium even when no external constraint was imposed. It is important, therefore, to investigate the effects of partial constraint, particularly in temperature ranges where metallurgical effects are likely to be encountered. As yet, little information has been obtained on this subject. However, from an experimental point of view, a convenient way to simulate partial constraint is to make use of the cam-driven apparatus already mentioned.[4] The degree of constraint can then be varied by permitting different amounts of displacement between the ends of the specimen for a fixed range of temperature cycling.

Data comparing full and partial constraint shown in Fig. 30 are for type 347 stainless steel.[8] Number of cycles to failure is plotted against the mechanical-strain range, that is, the total mechanical strain, elastic plus plastic. The data points represented by the circles indicate the life under full constraint for various amounts of mechanical-strain range. These strain ranges were changed by increasing the maximum temperature of the cycle while maintaining the minimum temperature at a constant value of 100 C. The triangles represent the life under partial constraint, for which the temperatures were maintained constant, with cycles occurring between 100 and 600 C, but the mechanical strain was varied by changing the amplitude of the cam motion. For a given mechanical-strain range, the number of cycles for partial constraint is considerably less than the number of cycles to failure for complete constraint. This result is to be expected since, for a given mechanical strain, the mean temperature is higher, 350 C, for the partial constraint than for the complete constraint where the mean temperature was always less than 350 C. For the complete constraint, the maximum temperature was always less than 600 C while the minimum temperature was maintained at 100 C. At the higher temperatures, more of the total mechanical strain consists of plastic strain, and metallurgical effects are more likely to be encountered. Hence, life is reduced. It would appear that, if the plot were based on true plastic strain per cycle rather than on total strain, the curves might become coincident. If this is the case, plastic strain per cycle becomes the correlating variable, independent of the degree of contraint.

The next article in this series will continue the analysis of thermal stresses in ductile materials with a discussion of the effect of thermal-stress cycling on mechanical properties, the effect of prior straining on thermal-stress fatigue resistance, correlations of and differences between thermal-stress fatigue and mechanical fatigue, and practical applications of thermal-stress fatigue data.

REFERENCES

This article is the fourth in a series by S. S. Manson on thermal stresses in design. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" ..... June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" August 7, 1958

Other references mentioned in this current article are:

4. L. F. Coffin Jr.—"An Investigation of Thermal-Stress Fatigue as Related to High Temperature Piping Flexibility," *ASME Paper* 56-A-178, 1956.
5. F. J. Clauss and J. W. Freeman—"Thermal Fatigue of Ductile Materials," Parts I and II, *NACA Technical Note*, to be published.
6. L. F. Coffin Jr.—"A Study of Cyclic-Thermal Stresses in a Ductile Material," *Trans. ASME*, Vol. 76, 1954, pp. 931-950.
7. H. H. Chiswick—"The Plastic Deformation of Uranium on Thermal Cycling," *Trans. ASME*, Preprint No. 21, Vol. 49, 1956.
8. L. F. Coffin Jr.—"Design Aspects of High Temperature Fatigue with Particular Reference to Thermal Stresses," *Trans. ASME*, Vol. 78, 1956, pp. 527-532.

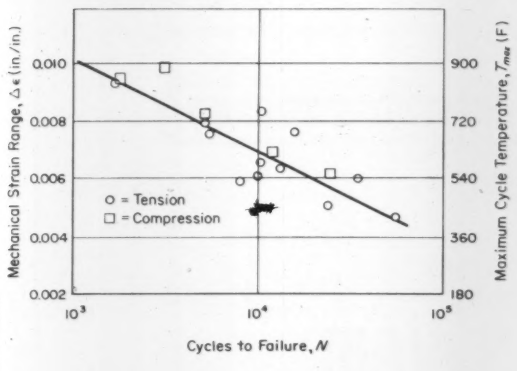


Fig. 29—Fatigue life as affected by tension or compression at maximum cycle temperature

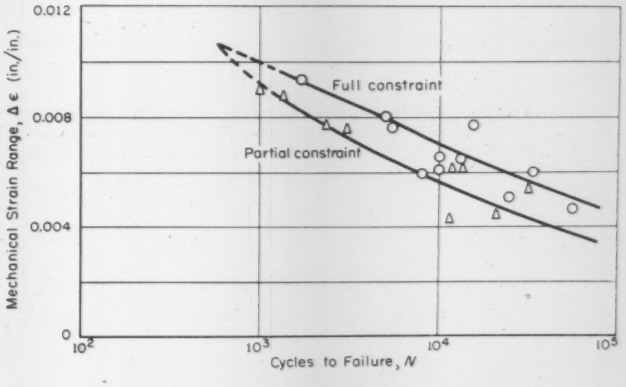
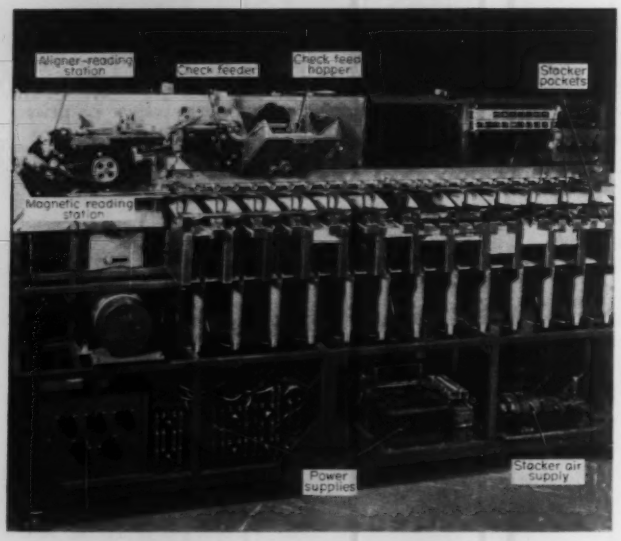


Fig. 30—Comparison of cycles to failure under partial constraint and constant mean temperature, and under full constraint with varying mean temperature

Automatic Reading and Sorting of

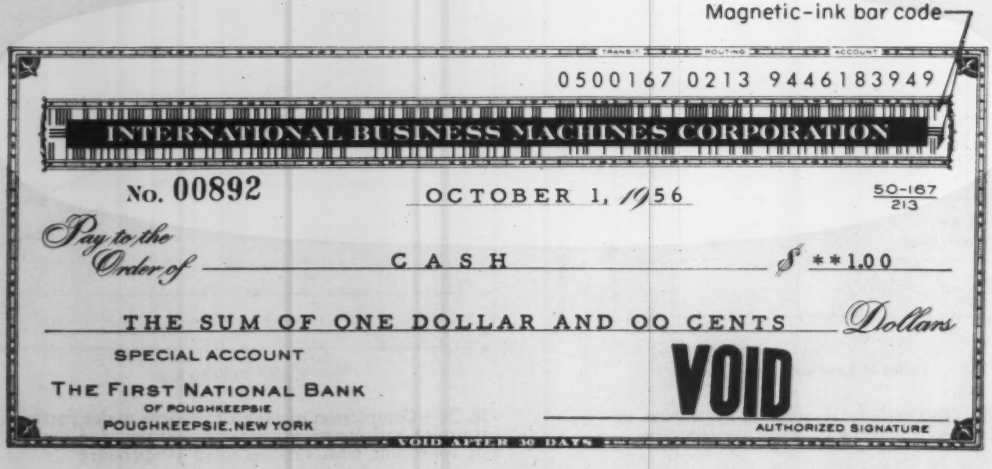
BANK-CHECK SORTER-READER is developed to handle intermixed documents of various sizes at speeds up to 650 per minute. As reported by J. A. Weidenhammer, senior engineer, IBM Product Development Lab at Poughkeepsie, N. Y., this machine reads and sorts paper or card checks of any size within the limits of 6¼ to 8¾ in. long and 2¾ to 3½ in. wide.



Used as a sorter, the machine's magnetic sensing head reads a two-track code which has been previously imprinted on each check with magnetic ink. The account number, transit number, and routing symbol are precoded, being imprinted at the time check forms are personalized with the depositor's name. The remaining fields of the code are recorded when the check is received at the paying bank.

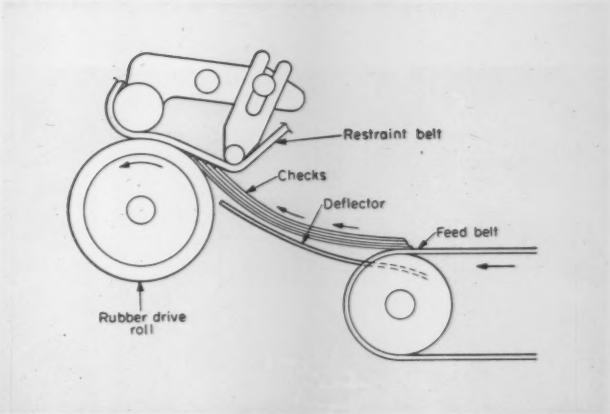
Based on information read from the checks, the machine automatically directs each document into one of thirteen stacker pockets. After several reruns through the sorter, which reads a successively lower denomination in the code control field during each run, the checks are arranged in proper sequence for each depositor.

Used as a reader, the machine sends information to an electronic computer which has a random-access memory attached. In a typical bank application, the memory may store current balances and other data for 60,000 or more depositors. A single run of unsorted checks or deposit tickets produces a completely updated customer account record in the random-access memory. Checks can be posted at rates up to 300 per minute.

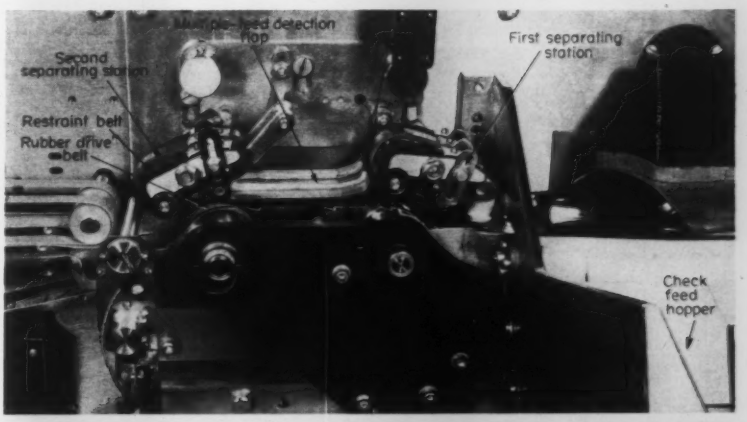


Intermixed Random-Size Checks

AUTOMATIC FEEDING of checks of mixed size is accomplished without accurate jogging of the deck to register one or more edges. The basic separating action of the new paper-feed mechanism is produced by a restraint belt wrapped around a portion of the circumference of a friction roll. Thus checks are separated over an extended area rather than in a narrow zone. As soon as the trailing edge of the first check begins to leave the friction roll, the next check which was above the first is moved along in close succession.



MULTIPLE FEEDING of checks is prevented with a second identical separation station operated in tandem with the first. Between these two stations is a flap which normally rests in a horizontal position. If two or more checks do get through the first separator, the top one or ones will buckle and raise the flap upon reaching the second separator. This action operates a contact, stopping station 1 until station 2 reduces the multiple feed.



SKEWED ALIGNING ROLLS tend to move the leading edge of the check to the right while it is simultaneously wrapped in an arc around the code-sensing drum. While the leading edge of the check moves inward, the remainder of the check is pivoted about the rounded corner of an oblique guide. Soon the check is moving in a straight line with its top edge pressed tightly against the flange of the aligning and reading drum.

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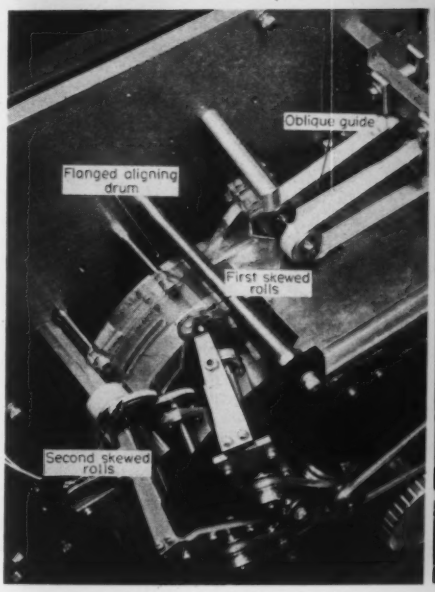
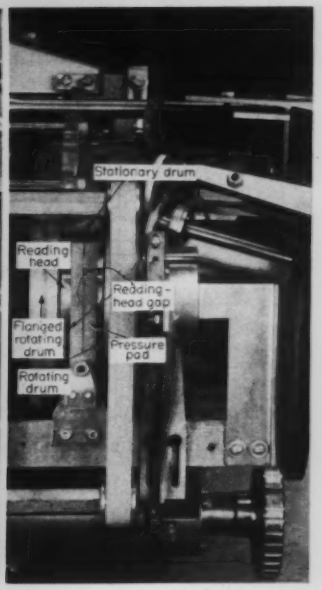
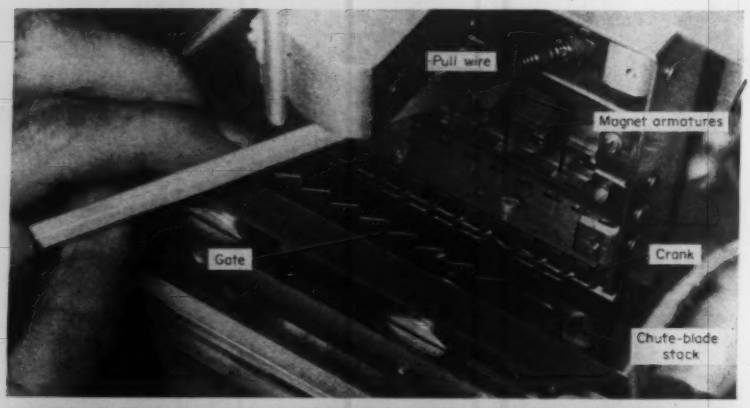
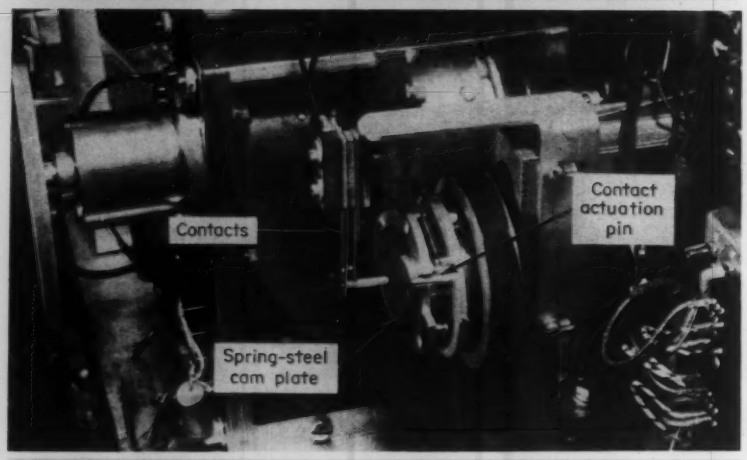
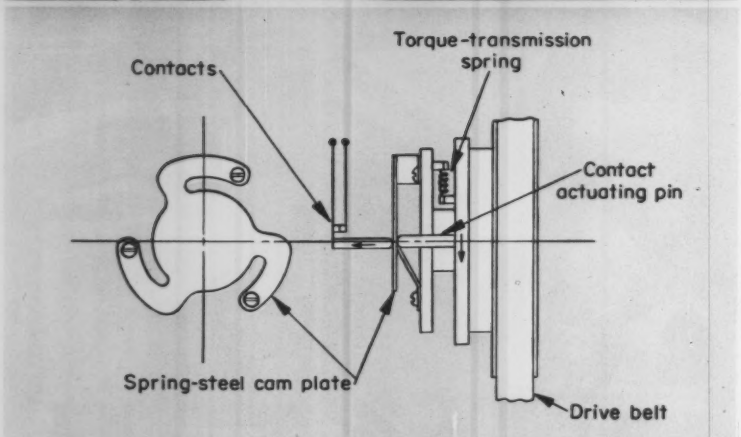




Automatic Sorting of Checks







Jam-Detection Switch Assembly

STACKER-POCKET DESTINATION of a given check is controlled by a magnetic reading head which is located in a stationary housing between two rotating drums carrying the check. When a magnetic bit (one of the vertical magnetic-ink code marks) crosses the 0.003-in. reading-head gap, the reduction in reluctance of the magnetic circuit increases the flux linking the coils and induces a signal output of 30 to 100 mv to an amplifier.

The signals from the reading head are decoded in the control circuits and operate magnets in the chute-blade selector unit which sorts the checks. Twelve chute blades 0.0005-in. thick are used to direct checks into any one of thirteen stacker pockets.

JAM-DETECTION MECHANISM minimizes damage to documents in case of misfeeds or pile-ups. In operation this torque-sensing device drives an output shaft by torque-transmission springs interposed between the output shaft and the drive pulley. When drive torque exceeds a certain value, these springs stretch, permitting relative rotation between input and output portions of the device. This rotary motion moves an actuation pin axially against a thin spring-steel cam plate stopping the machine.

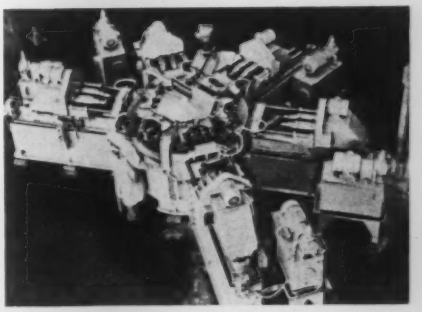
ACKNOWLEDGMENT

The author acknowledges with appreciation the assistance of the following in developing this machine: E. L. Fritz, A Kennedy, E. M. Valehrach, R. E. Edminster, and R. J. Furr.

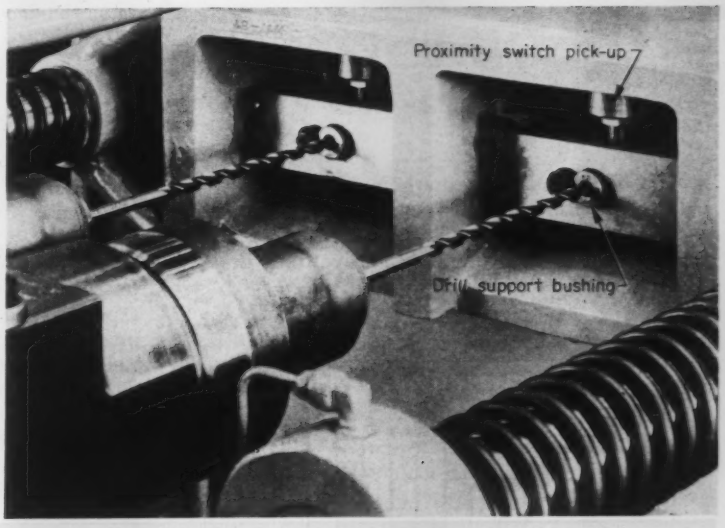
Drills Form Part of Electrical Control Circuit in Automatic Machine

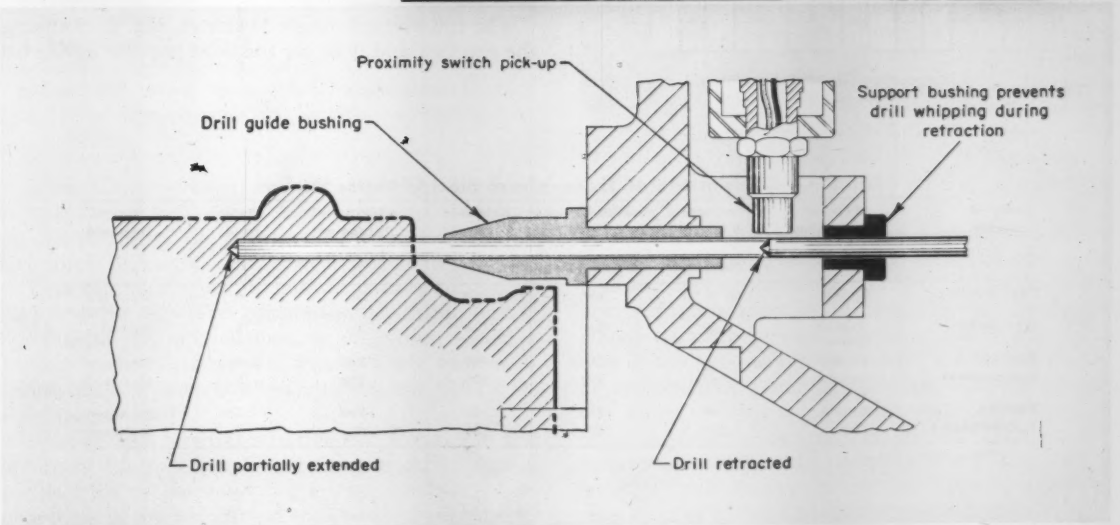
AUTOMATIC POWER SHUTOFF in case of drill breakage is feature in a new multiple-station indexing machine. Developed and built by the Buhr Machine Tool Co., Ann Arbor, Mich., the machine is designed to drill 1/4-in. oil-passage holes 7 3/4 in. deep in an automobile steering-gear housing. The holes are drilled in five passes, with each pass adding depth to the hole but with a slightly smaller diameter.

Five hydraulic-feed units are arranged around an automatic six-position index table. Drilling cycle time at each station is 27 sec.



PROXIMITY SWITCH PICK-UP is located at a set distance from the drill and between the two bushings. When drill is full retracted, its point is directly under the midpoint of this pick-up. The drill provides a path for magnetic flux lines which initiate an electrical control circuit. If the drill breaks, the circuit is broken and this amplified signal shuts down the machine.





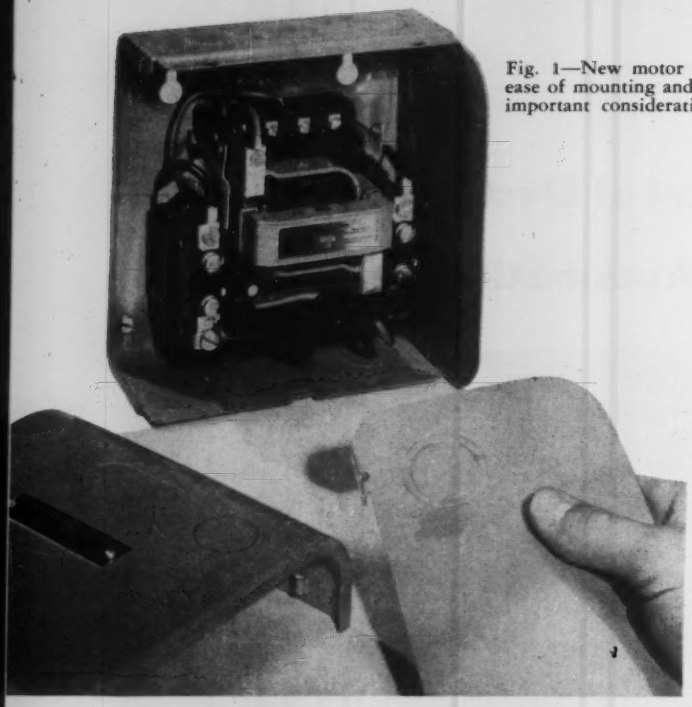


Fig. 1—New motor starter designed for ease of mounting and wiring, which is an important consideration during selection

How to select controls for

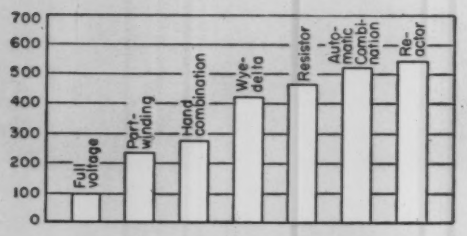
Starting Three-phase Motors

By JACK KILCOIN
Application Engineer
General-Purpose Control Dept.
General Electric Co.
Bloomington, Ill.

MOTOR starters exist solely to connect an electric motor to its power supply. The best starter is always the simplest and least expensive device that will satisfactorily fulfill the requirements of the application. For a small, single-phase motor, the starter may be a simple on-off toggle switch.

Integral-horsepower ac motors are usually three-phase, and the starting devices are more complex and expensive than with fractional-horsepower or single-phase motors. These starters range from relatively simple, across-the-line units for small squirrel-cage motors to extremely complex equipment for starting large synchronous motors, Table 1. Since across-the-line starters have the disadvantage of causing heavy current inrush, reduced-voltage starters are frequently employed, although they are more expensive.

The full-voltage magnetic starter, Fig. 1, is among the simplest and is by far the most popular device for



Comparative Starter Selling Prices
(for 30-hp, 220-v motors)

Table 1—Comparison of Three-phase Electric Motor Starters

Class of Starter	Type of Transition	Line Current (% of full-voltage line current)	Starting Torque (% of full-voltage starting torque)	Effective Torque	Adjustable Torque or Current	Motor Leads (quantity)	Motor Required
Part-Winding	Closed	60 to 70	40*	60	No	6	Standard or special
Wye-Delta	Open or closed	33	33	100	No	6	Special
Resistor	Closed	65	42	65	Yes	3	Standard
Compensator	Open or closed	42	42	100	Yes	3	Standard
Reactor	Closed	65	42	65	Yes	3	Standard
Full-Voltage	None	100	100	100	No	3	Standard

*With dips

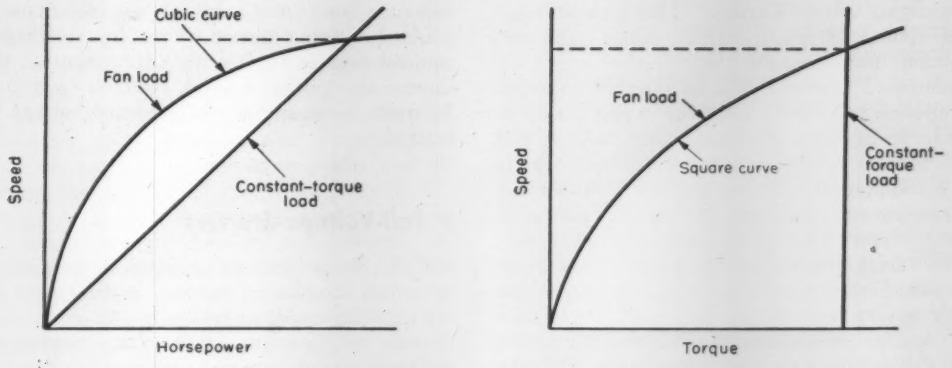


Fig. 2—Characteristics of constant-torque and fan loads

starting integral-horsepower, squirrel-cage motors. Since the magnetic contactors and relays in the starter are operated by a pilot control, it has an advantage over manual control in that the starter can be operated either automatically or remotely.

▶ *Starter-Selection Sequence*

There are five steps in the natural sequence of selecting an electric motor and its control.

1. Determine the load characteristics—torque and the horsepower-speed relationship.
2. Consider factors such as environment, power supply, space requirements, efficiency, and operating personnel.
3. Select a suitable motor.
4. Select an appropriate control.
5. Determine which motor-control combination is the most economical and also satisfies application requirements.

Load Characteristics: Curves giving the load torque, the horsepower-speed relationship, and data on the inertia of the drive, will immensely simplify the work of motor and control selection.

Two common types of loads are constant-torque and fan, Fig. 2. The constant-torque load, typical in machine-tool applications, is sometimes called a friction load. Some types of friction loads, such as in looms, may depart considerably from the ideal constant-torque load.

The fan load requires a torque which varies as the square of the speed and a horsepower which varies as the cube of the speed. Fans are typical of this type load, as are centrifugal compressors and pumps.

It is necessary to know the inertia of the load, WK^2, and the average accelerating torque to calculate the acceleration time, which is given by

$$t_{acc} = \frac{WK^2(\Delta S)}{308\ T_{avg}}$$

where WK^2 = total moment of inertia of load and motor, lb-ft^2; t_{acc} = accelerating time, sec; ΔS = difference in speed, rpm; and T_{avg} = average accelerating torque, lb-ft. Accurate determination of the acceleration time will aid in selecting relay heaters and circuit-breaker trip coils from the manufacturer's data.

Often, it is difficult to determine motor characteristics and acceleration time before construction of a prototype machine. However, if speed adjustment is not required, a squirrel-cage induction motor, which will provide the load requirements at full speed, can be selected. It will accelerate according to its speed-torque characteristic if it has adequate starting torque and capacity for the load-torque peaks.

In addition to the load torque-speed and horsepower-speed characteristics, two other aspects of the load should be considered: 1. Necessity for reversing or speed adjustment. 2. Effect of shock from full-voltage starting or rapid reversal. After consideration of the load and environment, a selection should be made among a standard, definite-purpose, or special motor. With a particular motor or motors in mind, the designer can consider control. The requirements of the load will dictate whether the control must provide for motor starting, speed regulation, reversing, or a combination of these.

Most three-phase, integral-horsepower motors are of the squirrel-cage induction type and are used in applications where only starting control is required. If the application is of this type, a selection must be made between full-voltage (across-the-line starting) or reduced-voltage starting. This decision must be based upon load characteristics, motor data, and power-system limitations.

As mentioned previously, it is possible to select a squirrel-cage induction motor for a given load at full speed. In this case, the horsepower, voltage, and full-load current of the motor selected are usually all that is required to select the control. Motors of a given horsepower produced by various manufacturers may have full-load currents which depart somewhat from the values given in Table 24 of the *National Electric Code*, and may also have either very high or very low starting currents. These cases deserve special consideration. However, during starting, the squirrel-cage induction motor will take approximately six times running current and develop about 200 per cent of running torque.

Power-system limitations are important in control selection since heavy starting currents may cause system-voltage fluctuations. Magnitude of these fluctuations depends on the distribution-circuit capacity. This may be a problem, particularly for small customers at the end of long radial feeders. Limitations and approved methods for avoiding motor-starting problems are given in local power-company regulations. Sometimes, control complications can be avoided by using normal-torque, low starting-current, squirrel-cage motors. With information on the load, motor, and power systems available, a decision can be made between full and reduced-voltage types of control.

Full-Voltage Starters

Full-voltage starters connect motors directly to, or across, the line on starting. A three-pole magnetic starter with overload relays in two motor leads will provide this function. Full-voltage starters are built by most manufacturers to meet numerous standards including: 1. *Standards for Industrial Control*, National Electrical Manufacturers Association. 2. *Standards for Safety-Industrial Control Equipment, UL* 508, Underwriters' Labs. Inc. 3. *JIC Electrical Standards for Industrial Equipment*, Joint Industry

Fig. 3—Basic circuit for a magnetic full-voltage starter

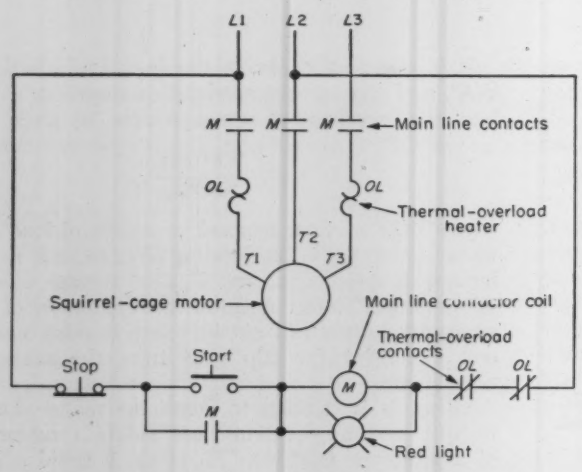
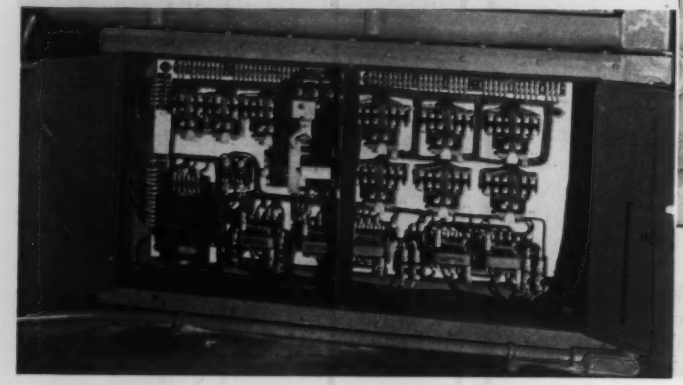


Fig. 4—Magnetic-starter panel for an automatic machine, demonstrating large space requirements of complex systems



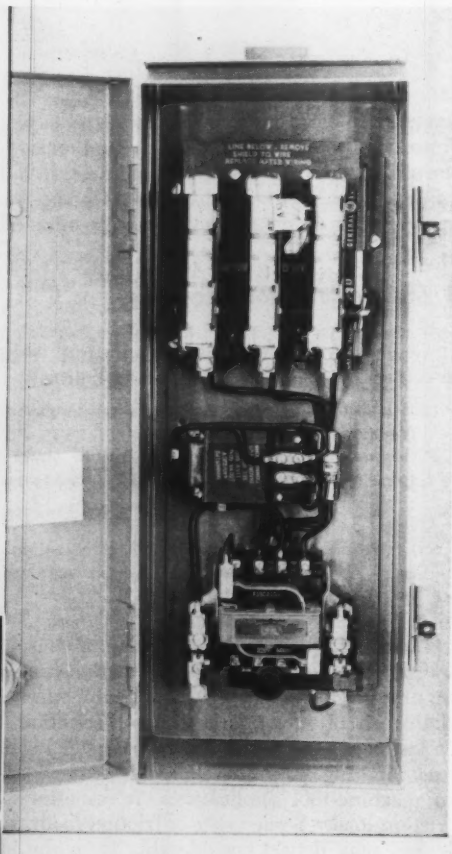


Fig. 5—Combination form of the full-voltage starter with a control transformer and fuses for circuit protection

(Automotive) Conference, 1957. Reference to these standards will give some background in evaluating control equipment and highlight some of the problems which exist in control design.

For example, NEMA requires that contact-tip temperature does not exceed 65 C, load and line terminals do not exceed 50 C, and temperature rise of coils does not exceed 85 C. Underwriters' Laboratories requires, for 600-v rated devices, that current-carrying parts be $\frac{3}{8}$ in. apart measured through air, and $\frac{1}{2}$ in. apart measured over an insulation surface. This spacing minimizes arc-overs and the resultant fire hazard.

The various standards include minimum performance requirements and safety requirements, but do not attempt to establish mechanical or load-life norms. Because of the variety of loads and operating conditions, it has been necessary to establish starter ratings empirically.

The ability of the starter to perform its function of interrupting the starting current is usually tested at ten times its rated motor current. This also tests the maximum overload resulting when the motor stalls. Contact life is largely determined by burning of the contacts on interruption—a function of confinement of the arc, configuration of the contacts for "blow-out" effect, use of insulating material or arc-chute inserts for arc cooling, and speed of contact opening. It is also important in current interruption to have a magnet design which will provide clean drop-out if the coil voltage drops due to line fluctuations. A design which permits the contacts to maintain low contact pressure or "kiss" position for even a short interval of time will result in severe heating and burning.

In addition to interruption, the starter must close on or "make" the starting-current inrush. Twice the rated motor-inrush current is standard for testing. The problem here is contact bounce on closing, which may result in severe arcing and welding of the contacts. Starter performance on make may be further improved by antiweld tips of cadmium-oxide silver alloys in place of fine silver. Here also, effect of low line voltage on closing must be considered and clean pickup is essential so that the contacts either remain open or fully closed.

Manual full-voltage or across-the-line starters—essentially toggle switches with overload protection—have advantages of low cost, small size, and simplicity. They are however, available only for low voltages and currents, and do not provide undervoltage protection, remote control, or automatic reset. Interlocking or auxiliary contacts also are limited or unavailable. For these reasons, magnetic control continues to be employed at over twice the volume of manual switches.

Basic circuit of a magnetic full-voltage starter is shown in Fig. 3. Completion of circuit by pressing the start button energizes the coil and closes starter contacts, including the one which forms a "sealing circuit" around the start button as long as voltage is available from the control-voltage source. The circuit provides undervoltage protection; the motor will not start on re-establishment of voltage after power failure unless the start button is again depressed. Since the magnet-coil inrush is up to 15 times holding current, the designer should select pushbuttons and auxiliary devices of adequate capacity.

Primary consideration when selecting a starter should be given to its performance, but features such as size, Fig. 4, ease of mounting and wiring, Fig. 1, wiring and servicing accessories available, and flexibility should also be considered since they assume major importance in some applications. Standards for starter rating have been established by NEMA for many years and only recently were changed to those shown in Table 2.

Protection against motor running overloads and stalls and the resultant fire hazard is provided by the National Electrical Code which requires overload protection. In the majority of cases this can be provided by two thermal relays, Fig. 1. Heaters, selected to suit the motor full-load current rating, simulate rise in temperature of the motor and cause a bimetallic or other type thermal element to open the control circuit and de-energize the starter magnet. Then, the starter contacts open, removing power from the motor. A reset button in the cover allows the relays to be reset after tripping, Fig. 1. An indicating light can also be located in the cover.

Combination form of the full-voltage starter, Fig. 5, has a branch-circuit short-circuit protection as required by the National Electrical Code. Installation cost is low. Overload relays provide running or stalled overload protection, but in case of short circuits in the motor or motor leads, currents can occur which, depending on capacity of the power system, may reach many thousands of amperes. They can be interrupted only by fuses or by circuit breakers.

Circuit breakers are available in compact, molded cases for voltages up to 600 v, the maximum voltage commonly used in industry. They can interrupt repeated short circuits without replacement and can be obtained with adjustable tripping times, but are generally slower in interrupting high short-circuit currents than are fuses. Circuit breakers have a magnetic tripping mechanism which will open the breaker when a preset current level is reached. Many breakers also have a thermal device similar to the starter overload relay. The additional ther-

Table 2—Size and Horsepower Ratings for Three-Phase AC Starters

NEMA Starter Size	Horsepower Ratings		
	110 v	220 v	440–550 v
00	¾	1	1
0	2*	3*	5*
1	3	7½*	10*
2	7½	15	25
3	15	30	50
4	25	50	100
5	..	100	200

*Ratings increased by new NEMA standards

mal elements protect the motor and wiring by tripping the breaker at currents less than the magnetic trip current setting if the currents are maintained long enough.

Fuses are used because of low first cost and fast operation. The latter feature is particularly important in protection of starters size 3 and smaller. Since construction of current-carrying parts such as relay heaters is relatively light, these starter sizes have low thermal capacity and are therefore unable to withstand temperature rise above the danger point for very long.

In addition to standard NEC fuses, current-limiting types are available which are designed for application on low-voltage circuits where short-circuit currents exceed interrupting capacity of the NEC fuse. The NEC fuse is tested only on 10,000 amp dc and considerable variations have been found in their performance on ac short circuits. However, modern designs of current-limiting fuses have an interrupting rating of up to 200,000 rms symmetrical amperes. Inadvertent replacement of current-limiting fuses with NEC fuses during maintenance can be avoided by use of rejection-type clips.

National Electrical Code Table 20 gives maximum size of circuit-breaker trip or fuse ratings, which range from 150 to 300 per cent of full load current, depending on type of motor. However, the rating may be increased to 400 per cent if the breaker trips or the fuse blows on motor starting. In the case of current-limiting fuses, because of their higher cost and the greater available short-circuit current involved, a careful co-ordination study should be undertaken using the manufacturers' fuse-characteristic curves.

▶ Reduced-Voltage Starters

If damage may occur, or if the power supply will be disturbed, by full-voltage starting, reduced-voltage starting should be considered. There are four main types: 1. Compensator or auto-transformer. 2. Reactor. 3. Resistor. 4. Reconnection. In all of these types, reduction in starting current and voltage is accompanied by a reduction in motor starting torque which varies as the square of the applied voltage. For this reason, the designer should compare the motor and load speed-torque characteristics.

Compensator: One form of the compensator-type, reduced-voltage starter employs an autotransformer in addition to three magnetic contactors connected as shown, Fig. 6. When the start button is pressed, the start contactor and the wye contactor are energized and the motor starts. Time-delay contacts on the start contactor de-energize the wye contactor at a preset time and energize the run contactor which has an auxiliary contact that de-energizes the start contactor. The sequence of operations provides a closed transition from start to run position.

This particular arrangement results in minimum supply disturbance since the voltage on the motor is changed without actually opening the circuit. Compensators provide the highest torque per ampere drawn from the line and are therefore a most ef-

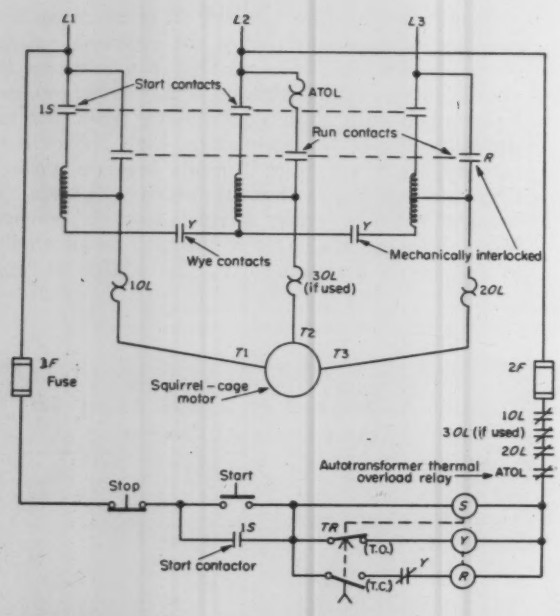


Fig. 6—Closed-transition compensator starter employs an autotransformer and three magnetic contactors

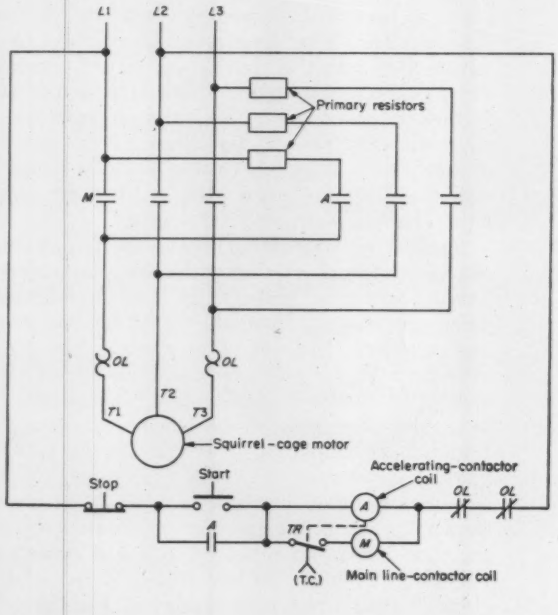


Fig. 7—Typical circuit for employment of primary-resistor starter

ficient means of reduced-voltage starting. Manually operated compensators are also available.

Resistor: Primary-resistance starters are used with a circuit similar to that in Fig. 7. Two or more operating points may be provided for speed regulation. Reduction in current is not as great for a given torque as with a compensator, but the initial cost is considerably less and acceleration is very smooth since the torque constantly increases as the motor comes up to speed.

Reactor: These starters are similar in construction to primary-resistance starters except for the use of reactors. Resultant reduction in size and heat losses during the starting period are particularly valuable in starting large motors but the power factor is adversely affected.

Reconnection: Part-winding starters are employed with motors having dual-voltage windings which can be connected in wye or delta for either ½ or 2/3-winding starting, Fig. 8. The four-pole contactor closes first and energizes 2/3 of the winding; after a time delay, the two-pole contactor closes. This starter is generally used where the load starting torque is low, such as in fans and centrifugal pumps.

The wye-delta starter employs another type of reconnection. Here, the motors have two windings —wye for starting and delta for running. Only a low starting torque is available, limiting usage to light loads. In both wye-delta and part-winding starters, adjustable time-delay relays provide for winding change at the appropriate time.

▶ *Speed Regulation*

If the load requires speed regulation, several alternatives are available, such as multispeed motors, brush-shifting ac motors, or wound-rotor motors. Kraemer and frequency-changer sets will provide flexibility of speed control and high standards of performance, but are expensive and thus are used in limited quantities.

Multispeed Motor Control: Squirrel-cage motors can be designed as multispeed motors with as many as four separate stator windings, the whole or portions of which may be connected by appropriate control to provide different speeds. The diagrams are often very complex but the arrangement is used in relatively small numbers on fans, conveyor drives,

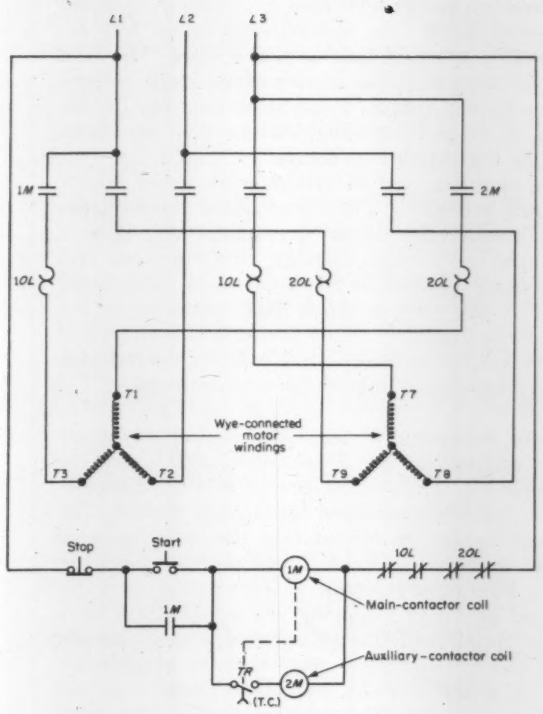


Fig. 8—Part-winding starter on a dual-voltage motor which is wye-connected and uses 2/3 of winding for starting

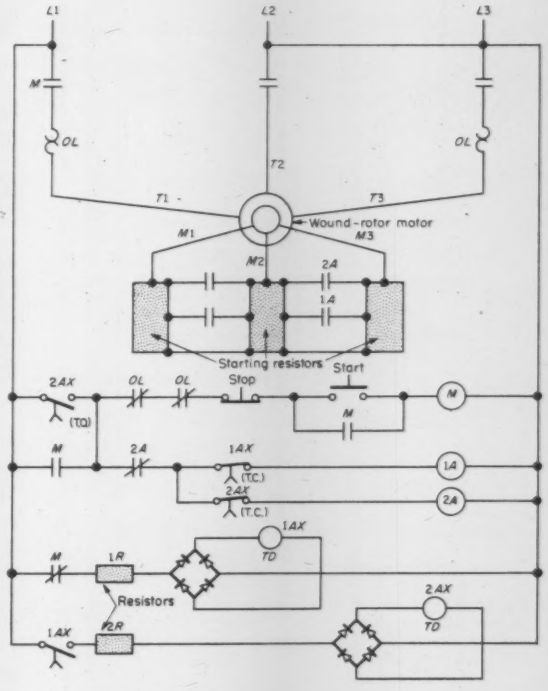


Fig. 9—Starter circuit with definite, automatic time delay for wound-rotor motors to avoid overheating of resistors

and mixers where the large speed ratios imposed are satisfactory.

Brush-Shifting AC Motor: Speed adjustment can also be obtained from specially designed brush-shifting, commutator-type ac motors which provide speed ranges up to 20:1 by a small pilot motor mounted on the main motor. The control consists simply of a magnetic full-voltage starter for the main motor and a small relay to control the speed-adjusting pilot motor through a pushbutton station.

Wound-Rotor Motors: Although used on mine hoists, crane hooks, centrifugal compressors, and similar applications, speed regulation is poor and varies with changes in load. Dynamic braking is sometimes necessary. Acceleration with reduced torque and starting current can be provided by wound-rotor motor control and performance is actually better than a combination of a compensator and squirrel-cage motor, in the sense that a higher torque is available for given starting current.

The wound-rotor stator or primary is similar to the squirrel-cage motor; thus, the primary control is also similar. Secondary or rotor windings are, however, brought out to slip rings so that various amounts of resistance can be inserted in series for speed adjustment.

Power and control circuits involved in one type of wound-rotor motor starter are shown in Fig. 9. The control circuits are more elaborate than those previously mentioned; for example, electrical interlocking is used to assure starting with full resistance in the secondary. Automatic time-delay operation is provided to avoid overheating of intermittent-rated resistors due to tardy acceleration. Automatic operation also prevents resistance from being reduced too quickly.

Synchronous Motors: These motors can be selected to improve power factor of a system and/or to power constant-speed drives. They are similar to induction motors except for an additional field, located in the rotor pole faces, which is supplied with dc current. This design allows the motor to be started as an induction motor and then to be run synchronously.

The stator-circuit control consists of a motor starter, same as used for induction motors. Either full-voltage or reduced-voltage starters can be used. The rotor circuit control includes equipment for:

1. Applying dc excitation to motor field.
2. Removal of field excitation when motor pulls out of synchronism.
3. Selection of correct speed and phase cycles for field application and removal.
4. Discharging dc field on opening.
5. Special overload relays for protection of squirrel-cage windings.

Relatively complex control is required since the synchronous motor will come to a stop if the field is applied before the squirrel-cage motor has accelerated to a satisfactory operating speed. The field must be applied at the correct phase angle to provide sufficient torque for synchronization. In addition, a large fluctuating current will be drawn from the line if pull-in is delayed.

The simplest type of synchronous motor starter is shown in Fig. 10. The circuit illustrates the principles involved but is not a practical one, since it is usable only when starting with no load and where rotor position at the moment of field application is not critical. Also, field excitation is not removed immediately when the motor pulls out of step because of an overload. Thus, the squirrel-cage starting winding is not sufficiently protected.

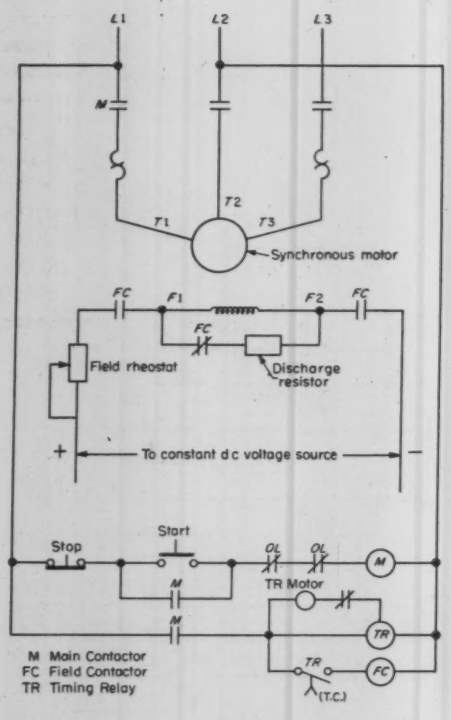
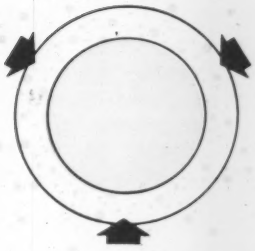


Fig. 10—Simplified synchronous-motor starter circuit with definite-time field application

Motor Reversing: If the load requires the motor to reverse, two of the three motor leads should be interchanged. The circuit requires two mechanically and electrically interlocked full-voltage starters. The designer should be certain that the motor selected is able to stand mechanical and thermal shock resulting from rapid reversal.

Rapid or "plug" stopping can be obtained by a similar circuit with the addition of a speed-sensing relay which will remove reverse power immediately prior to actual reversal, and allow motor and load to coast to a stop. This requires that the contactor open what is practically a stalled-rotor current: NEMA Standard IC 1-21.05 requires use of a lower horsepower rating for starters on plug-stop or jogging duty of more than five times per minute.



Resistance of thermoplastics to chemicals can be determined by information on two properties—solubility and permeability. New data on solubility are presented here which show how various liquids attack the plastic. Also included are permeability values which indicate the effectiveness of a thermoplastic as a protective barrier.

Chemical resistance of

Thermoplastic Materials

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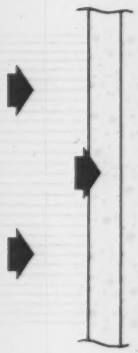


WHEN designers are confronted with applications involving the property of so-called "chemical resistance," a general lack of basic engineering data concerning solubility and permeability of thermoplastics often makes it extremely difficult to select an optimum material for the application. Yet, these properties are of particular significance to designers in evaluating a thermoplastic which has been chosen for its chemical stability.

Stress Corrosion: Plastics are, to a great degree, subject to environmental conditions. Problems of stress-corrosion cracking are much more pronounced with plastics than with metals. For this reason, designers should not hesitate to conduct evaluation tests on thermoplastics in accordance with certain parameters prior to final acceptance of the material. Recommended parameters include those which indicate types and nature of stresses in thermoplastics. These stresses, both inherent and applied are:

1. Internal residual stresses which are functions of processing conditions.
2. Tensile, shear, or compressive stresses either uniaxial or multiaxial.
3. Short and long-time ultimate stresses.

In addition, many plastics are subject to development of fine cracks at right angles to an applied stress. This condition, called crazing, can be produced by mechanical forces, by chemical action, or by a combination of both.

Solubility of Thermoplastics: To establish the chemical stability of thermoplastics, a commercial polyethylene was compression molded, stress relieved, and measured for solubility and thickness changes with 54 common liquids. Polyethylene was selected for the test because it is commonly regarded as being chemically inert. However, there is no known liquid, including water, which does not tend to swell or shrink this thermoplastic even when the plastic is in the unstressed state. Table 1 shows solubility of test materials in polyethylene at various temperatures.

These values of solubility were obtained by immersing polyethylene strips in the test fluids or permeants. The solubility figures, weight increases, in Table 1 are values at equilibrium expressed in grams (increase) per gram of polyethylene.

Regarding thickness changes, it may be said that polyethylene strips, when immersed in various fluids,

Table 1—Solubility of Test Materials in Polyethylene at Various Temperatures*

Permeant	32 F Solubility (grams/gram)	32 F Thickness Change (per cent)	70 F Solubility (grams/gram)	70 F Thickness Change (per cent)	100 F Solubility (grams/gram)	100 F Thickness Change (per cent)	130 F Solubility (grams/gram)	130 F Thickness Change (per cent)
Sulphuric acid (per cent)								
36	0.0004	0.583	0.0004	0.165	0.0004	0.428	0.0006	0.835
55	0.0004	0.658	0.0005	0.478	0.0006	0.555	0.0006	0.549
93	0.0004	0.470	0.0006	0.380	0.0005	0.474	0.475	0.320
Hydrochloric acid (per cent)								
20	0.0009	—0.131	0.0007	—0.105	0.0008	0.002	0.0011	0.320
36	0.0020	0.105	0.0013	0	0.0018	0.274	0.0025	0.389
Nitric acid (per cent)								
20	0.0011	0.274	0.0009	0.161	0.0018	—0.107	0.0143	0.153
67	0.0039	—0.109	0.115	0.050	0.0246	3.04	0.1720	1.47
Phosphoric acid	0.0019	0.155	0.0021	0.148	0.0012	0.861	0.0015	0.220
Fluoboric acid	0.0013	0.225	0.0008	0.930	0.0012	0.166	.....	....
Hydrofluoric acid	0.0014	0.328	0.0013	0.329	0.0011	0.482	0.0016	0.207
Sodium hydroxide (per cent)								
10	0.0005	0.211	0.0007	0.057	0.0009	0.688	0.0008	0.583
40	0.0009	0.054	0.0009	0.279	0.0009	0.055	0.0013	0.159
Aqua ammonia (per cent)								
10	0.0005	0.164	0.0003	0.428	0.0008	0.112	.....	....
28	0.0009	—0.110	0.0009	0.169	0.0011	0.383	.....	....
Formic acid	0.0018	—0.273	0.0026	0.463	0.0036	0.214	0.0042	1.049
Acetic acid (per cent)								
56	0.0020	—0.055	0.0029	—0.319	0.0026	—0.052	0.0040	0.680
99	0.0080	—0.371	0.0103	0.323	0.0124	—0.106	0.0285	0.479
Methyl alcohol	0.0010	—0.053	0.0010	0.105	0.0010	—0.053	0.0012	0.228
n-Propyl alcohol	0.0021	0.007	0.0032	0.156	0.0053	—0.102	0.0086	0.517
n-butyl alcohol	0.0041	0.112	0.0058	0.393	0.0084	0.362	0.0125	0.771
Sec-Butyl alcohol	0.0057	—0.331	0.0101	0.269	0.0178	0.259	0.0253	0.640
Tert-Butyl alcohol	0.0073	0	0.0111	0.161	0.0161	0.385	0.0265	0.795
n-Octyl alcohol	0.0067	0.212	0.0134	0.0003	0.0172	0.109	0.292	0.590
Ethylene glycol	0.0028	0.214	0.0029	0.156	0.0044	0.436	0.0064	0.704
Glycerine	0.0068	—0.272	0.0072	0.159	0.0088	0.278	0.0096	0.010
Diethylene glycol	0.0033	0.105	0.0031	—0.114	0.0061	—0.275	0.0075	—0.107
Butyl cellosolve	0.0065	0	0.0095	0.435	0.0129	0.273	0.0208	0.442
Ethyl acetate	0.0218	0.337	0.0273	0.477	0.0353	0.866	0.0466	0.796
Amyl acetate	0.0283	0.656	0.0390	1.072	0.0551	1.102	0.0896	2.680
Dibutyl phthalate	0.0058	0.053	0.0125	0.397	0.0169	0.219	0.0247	0.851
Diethyl ether	0.0760	3.140	0.0800	3.280	.....	....	.....	....
Dibutyl ether	0.0728	1.690	0.0923	3.120	0.1237	4.270	0.1783	4.732
Formaldehyde	0.0065	0.115	0.0045	0.395	.....	....	.....	....
Acetaldehyde	0.0196	0.727	0.0270	0.820	.....	....	.....	....
n-Butyraldehyde	0.0227	0.690	0.0302	0.904	0.0412	0.591	0.0558	0.687
Benzaldehyde	0.0188	0.107	0.0251	0.664	0.0334	1.403	0.0504	2.773
Acetone	0.0095	0.595	0.0127	0.604	0.0157	0.507	.....	....
Methylethyl ketone	0.0175	0.633	0.0225	0.784	0.0282	1.089	.....	....
Diacetone alcohol	0.0037	0.005	0.0050	—0.329	0.0072	0.278	0.0192	0.483
Acetic anhydride	0.0029	—0.336	0.0031	—0.269	0.0048	0.108	0.0069	—0.402
Turpentine	0.1212	4.120	0.1745	5.330	0.2528	8.720	0.4291	13.633
Dipentene	0.1101	2.580	0.1496	4.713	0.2166	6.610	0.2729	8.363
Aniline	0.0071	0.056	0.0102	0.216	0.0142	0.161	0.0214	0.277
Isopropyl amine	0.0377	2.020	0.0499	2.313	0.0625	2.800	.....	....
Nitroethane	0.0043	—0.173	0.0059	0.430	0.0076	0.613	0.0119	0.548
Nitrobenzene	0.0172	0.568	0.0244	0.712	.....	....	.....	....
n-Pentane	0.1058	4.840	0.1120	5.710	.....	....	.....	....
Isopentane	0.0981	3.090	0.1061	4.260	.....	....	.....	....
Pentane-2	0.1156	1.600	0.1212	5.430	.....	....	.....	....
n-Heptane	0.1030	4.510	0.0113	5.100	0.1539	5.760	0.2220	9.070
Decane	0.0852	2.750	0.1055	2.950	0.1469	4.690	0.2134	7.200
Tetradecane	0.0650	2.540	0.0962	2.550	0.1547	4.390	0.1756	5.750
Lubricating oil	0.0398	1.080	0.0827	2.110	0.1498	3.690	0.2060	5.270
Benzene	0.1444	4.300	0.1546	5.113	0.2080	6.460	0.2940	8.850
o-Xylene	0.1613	5.120	0.1914	6.680	0.2804	8.820	0.5554	14.400
p-Xylene	0.1693	5.440	0.1863	5.710	0.2630	7.880	0.4180	12.200
Cyclohexane	0.1949	6.000	0.2208	8.950	0.3291	11.700	0.7045	17.070
Chlorobenzene	0.1869	3.820	.....	....	.....	....	0.5316	11.20
p-Chlorotoluene	0.1720	4.480	0.1989	5.750	0.2688	6.720	0.4922	11.940
Hydrogen peroxide (per cent)								
3	0.0011	—0.120	0.0009	0.218	.....	....	.....	....
30	0.0011	0.292	0.0010	0.265	.....	....	.....	....
Silicone oil	0.0063	—0.070	0.0069	—0.605	0.0044	—0.105	0.0046	0.101
Water	0.0006	—0.140	0.0010	—0.111	0.0012	0.056	0.0028	0.161
Sodium hypochlorite	0.0016	0.155	0.0008	—0.054	0.0028	0.155	0.0033	—0.216

*Grams of test fluid dissolved in one gram of polyethylene.

Table 2—Permeability of Chemical-Resistant

Permeant	Polyethylene A 73 F	Polyethylene A 120 F	Polyethylene A (irradiated) 73 F	Polyethylene A (irradiated) 120 F	Polyethylene Resins: Polyethylene B (50 per cent Flakglass) 73 F	Polyethylene B (50 per cent Flakglass) 120 F	Polyethylene C 73 F	Polyethylene C 120 F	Polyethylene D 73 F	Polyethylene D 120 F	Polyethylene D (12.5 per cent butyl rubber) 73 F	Polyethylene D (12.5 per cent butyl rubber) 120 F	Polyethers Linear Acetal E 73 F	Polyethers Linear Acetal E 120 F
Water	0.16	2.87	0.12	3.06	0.85	2.93	[1]	1.59	0.05	3.21	0.78	3.90	5.87	41.0
Methanol	1.28	16.6	1.47	18.2	6.15	24.8	0.21	5.25	1.74	21.9	4.85	12.4	1.67	36.6
Acetic acid	3.76	42.1	4.46	45.9	...	...	0.97	5.96	...	...	...	...	...	...
Ethyl acetate	27.7	262	35.7	332	...	...	4.53	42.8	37.8	426	31.5	292	12.0	76.5
Methylethyl ketone	14.0	185	17.5	198	...	...	...	...	...	...	...	...	...	...
Acetone	...	...	...	...	18.5	113	...	...	12.2	142	9.46	351	18.6	131
n-Butyl ether	112	867	143	830	32.3	297	21.1	112	136	1400	143	489	0.29	1.52
n-Hexane	...	...	...	...	...	...	...	...	...	...	...	...	...	...
n-Heptane	303	2230	332	1940	...	...	52.2	275	...	...	...	...	...	...
n-Decane	...	...	...	...	...	...	...	...	1.43	946	...	...	0.11	0.60
Mineral oil	...	...	...	...	...	...	...	0.34	...	...	...	...	...	...
Benzene	494	3980	535	3570	...	...	...	...	...	...	...	...	...	...
Toluene	...	...	...	...	197	472	118	496	603	[3]	574	[3]	0.56	8.04
Dipentene	...	...	...	...	51.4	432	25.6	136	...	...	194	547	0.21	0.89
Turpentine	74.5	854	80	745	...	...	3.58	51.1	...	...	...	...	...	...
Carbon tetrachloride	...	...	...	...	233	1585	98.6	637	931	[3]	879	[3]	0.36	5.11

*Grams/24 hr/100 sq in./0.001-in. film thickness.
[1]No significant change.
[2]Tests made but results considered inaccurate.
[3]Extremely high permeation. Factor not calculated.
[4]Not applicable. Data not given.

may swell or shrink as indicated by the positive and negative values respectively in Table 1.

Permeability of Thermoplastics: Solubility alone is not sufficient for evaluating chemical stability of thermoplastics. Permeability, which is considered a corollary function, also plays an important role and is of value to the design engineer. A material which proves to be insoluble and chemical resistant may also be highly permeable. This is important in applications such as protective coatings, for example, where the plastic is chosen for its chemical or physical properties. In general, however, the more highly permeable materials have greater solvent action.

Permeability of plastic materials involves solubility, diffusion, and evaporation. Molecules of a given liquid in contact with the surface of a plastic film are dissolved into the plastic, migrate to the opposite surface, and evaporate from it. Where a plastic is used for a protective coating such as a drum liner, the evaporation phase may be absent because of the direct contact of the plastic with the protected surface. In such cases, the permeability value is lower than in instances where evaporation is possible. However, permeability values indicate effectiveness of the plastic as a protective barrier and can be used to predict the probability of corrosion of the protected member. Permeability values of various thermoplastics are shown in Table 2.

Effects of Time and Temperature: Permeability of a plastic increases with time, temperature, and exposed surface area of the plastic but decreases with increased thickness. For practical values, all effects increase arithmetically except temperature, in which case the effect is logarithmic. The plastics and permeants tested are representative of permeability. They vary in chemical composition, and effects of these differences are noticeable. The temperature effect, for example, is evident in the differences between the 73 and 120 F values.

The permeability values are intended as guides in initial material selection and should not be used as absolute determinants for a given application. Data in Table 2 indicate that the polyethylenes are better barriers to water and methanol than the nylons,

Identification of Plastic Resins Evaluated

Flakglass—Product of Owens-Corning Fiberglas Corp.

Delrin—Dupont's linear acetal resin.

Polyethylene A—A standard low-density (0.92) polyethylene of the Bakelite Co.

Polyethylene A (irradiated) — Low-density polyethylene irradiated at 26 megareps by the High Voltage Engineering Corp.

Polyethylene B—A standard low-density (0.92) polyethylene of the Bakelite Co. with 50 per cent Flakglass added. Not commercially available.

Polyethylene C—Representative of the high-density (0.96) polyethylenes by Phillips Chemical Co. This group has the highest density and crystallinity of the polyethylenes.

Polyethylene D—A low-density (0.92) general-purpose polyethylene of the U. S. Industrial Chemical Co.

Polyethylene D (12.5 per cent butyl-rubber)—Rubber added for research purposes.

Linear Acetal E—Dupont's Delrin.

Polyether F (chlorinated)—This thermoplastic (Penton) by the Hercules Powder Co. has a chemical structure completely different from other materials tested.

Nylon G—Dupont's 66 type nylon, high molecular weight extrusion.

Nylon H—Dupont's 66 type nylon, plasticized.

Polyvinylchloride K — Abbey Plastics Corp. rigid formulation.

Polyvinylchloride L — Abbey Plastics Corp. flexible formulation.

Monochlorotrifluoro M—Representative of the halogenated polymers by the Minnesota Mining & Mfg. Co.

Tetrafluoro N—A halogenated polymer by Dupont with properties similar to type M.

Thermoplastics at Various Temperatures*

Polyethers		Nylons				Vinyls				Haloethylenes				
Chlorinated F		Nylon G (nonplasticized)		Nylon H (plasticized)		Vinyl K (rigid)		Vinyl L (flexible)		Monochloro-trifluoro M		Tetra-fluoro N		Permeant
73 F	120 F	73 F	120 F	73 F	120 F	73 F	120 F	73 F	120 F	73 F	120 F	73 F	120 F	
0.02	1.43	4.30	58.6	25.2	222	0.73	5.5	1.85	[2]	0.19	...	[1]	0.89	Water
0.54	5.68	38.1	407	Solvent attack		1.35	6.95	4.9	...	0.14	...	1.37	5.61	Methanol
...	...	...	...	...	...	...	...	...	...	...	...	...	...	Acetic Acid
101	426	0.07	1.76	2.61	...	Solvent attack		Solvent attack		3.51	...	0.58	2.92	Ethyl Acetate
...	...	...	...	...	...	...	...	...	...	...	...	...	...	Methylethyl ketone
237	[3]	...	...	...	...	...	...	Solvent attack		3.32	...	0.13	3.29	Acetone
0.08	1.68	0.15	3.34	6.57	...	...	...	16.8	[2]	...	...	[4]	0.65	n-Butyl ether
...	...	0.32	7.8	...	...	...	...	...	...	...	...	...	...	n-Hexane
...	...	...	...	...	...	...	...	0.16	1.76	...	...	...	...	n-Heptane
0.15	0.56	...	...	0.42	3.89	...	...	...	...	...	...	0.72	1.03	n-Decane
[4]	0.29	0.74	1.91	...	...	...	...	...	...	...	...	...	...	Mineral Oil
...	...	0.57	7.9	1.76	16.6	...	...	...	...	...	...	...	...	Benzene
25.2	212	...	...	...	...	...	...	Solvent attack		1.52	...	0.37	2.93	Toluene
[1]	0.71	0.21	3.60	0.66	5.17	...	...	6.45	33.4	...	...	[4]	1.03	Dipentene
[4]	0.76	...	...	...	...	...	...	...	...	0.07	...	...	...	Turpentine
0.67	15.4	0.55	12.9	1.13	17.8	...	...	117	[2]	5.92	...	3.76	10.2	Carbon tetrachloride

while the nylons offer greater protection to the straight chain and aromatic hydrocarbons. There are instances, Table 2, where permeability of the plastic was so great that it was not calculated.

Effects of Polymer Density: Permeability properties of polyethylene change with the density of the polymer, with the high-density types proving less permeable. Irradiated polyethylene is generally more permeable at room temperature than non-irradiated polyethylene. Blending of Flakglass or butyl rubber with polyethylene does not greatly change permeability of molded containers but could appreciably alter permeability characteristics of film. The extent to which Flakglass lessens permeability depends upon how continuous a path it forms and how it is oriented within the plastic.

The nylons are more permeable to alcohol and water than any of the polyethylenes but are less permeable to hydrocarbons such as hexane and benzene. Solvation is evident in the vinyl resins, and solvent attack is present in the halogenated polymers. Permeability of chlorinated polyether to esters and ketones is noticeable. Delrin is of interest to design engineers because of its unusual toughness, dimensional stability, fatigue life, recovery from deformation, and good machinability.

Data in Table 2 indicate relative permeabilities only, but values may be used to determine which plastic is a better barrier in a given instance. However, if significant swelling occurs, the plastic has too high a permeability to be used. No attempt has been made to determine the permeability level at which a material may be said to provide satisfactory protection. However, permeability of polyethylene to some common acids and alkalis was determined and found to be of the same order as with water. These values, regarded as relatively low, are shown in Table 3.

Table 3—Polyethylene Permeability to Common Acids and Alkalis*

Permeant	70 F	130 F
Water	0.279	3.94
Sulfuric acid (per cent)		
36	0.631	3.04
50	....	2.03
68	†	1.21‡
93	†	0.35
Hydrochloric acid (per cent)		
20	0.12	2.63
36	0.85	6.92
Nitric acid (per cent)		
20	0.16	3.74
67	0.17	9.08
Sodium hydroxide (per cent)		
Solid	†	†
10	0.196	3.63
Ammonia (per cent)		
10	0.62	1.80
28	2.09	6.65

*Grams/24 hr/100 sq in./0.001-in. film thickness.
†Not applicable. Data not given.
‡Based on a 165-day test.

Tips and Techniques

Approximate Square Root

To find the approximate square root of a number, start with the nearest perfect square, either above or below the value of the number in question. Then divide the square root of the perfect square into the original number. Next, add the perfect square root to the quotient just obtained in the previous step and divide this sum by 2 to obtain the approximate square root of the number.

By repeating these steps, a square root of any desired accuracy may be obtained.—KENN CZARNECKI, *Solo Cup Co., Chicago, Ill.*

Example: Find $\sqrt{390}$

Step 1. $\sqrt{400} = 20$

Step 2. $390/20 = 19.5$

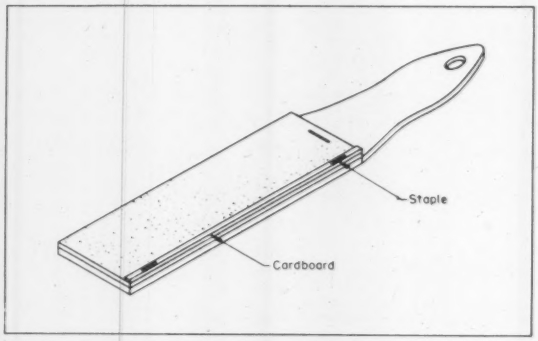
Step 3. $20 + 19.5 = 39.5$

Step 4. $39.5/2 = 19.75$

$\therefore \sqrt{390} = 19.75$ (approx)

Chuck Saver

Wear on the chuck of a mechanical lead-holder can be reduced when using a sanding block to sharpen the point. Just staple a strip of cardboard on the edge of the sanding block, as shown.—N. CHIARAVALLOTI, *Irvington, N. J.*



Numerical rules for designing

PLANETARY GEARS

By ROBERT L. BENFORD
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BECAUSE of particular merits, planetary gears are suited to a vast range of applications and sizes. But they also have particular problems due to centrifugal effects and multiple load paths. Planetaries pose other problems, too, because of moving parts; in other gear sets similar parts are fixed and accessible. These problems are not great obstacles to the successful design of a planetary gear drive. They can be solved or circumvented by proper sizing, proportioning, arranging, supporting, lubricating, etc.

However, there are other design considerations that involve purely numerical relations, such as number of teeth, number of planets, load-application cycles, and speed ratios. Some of these relations must be rigorously observed of necessity; careful attention to others benefits the final design. These relations are examined in this article and specific numerical rules and design recommendations are offered.

Speed Ratios: Planetary gears differ from other gears most obviously because the speed ratio is not the same as the tooth ratio, as in all fixed gear types, or the ratio of pitch diameters, as in all fixed-axis coplanar gears. The difference is in the planetary precession which can often be confusing, or at least disconcerting. Table 1 shows the relative rotative speeds of simple planetary gearing with various combinations of driving, driven, and fixed members. Table 2 gives the same information for compound or two-stage planetary gears.

These tables have proved to be useful and they give solutions easily and rapidly. However, the equations should be understood and their derivations checked before they are used the first time.

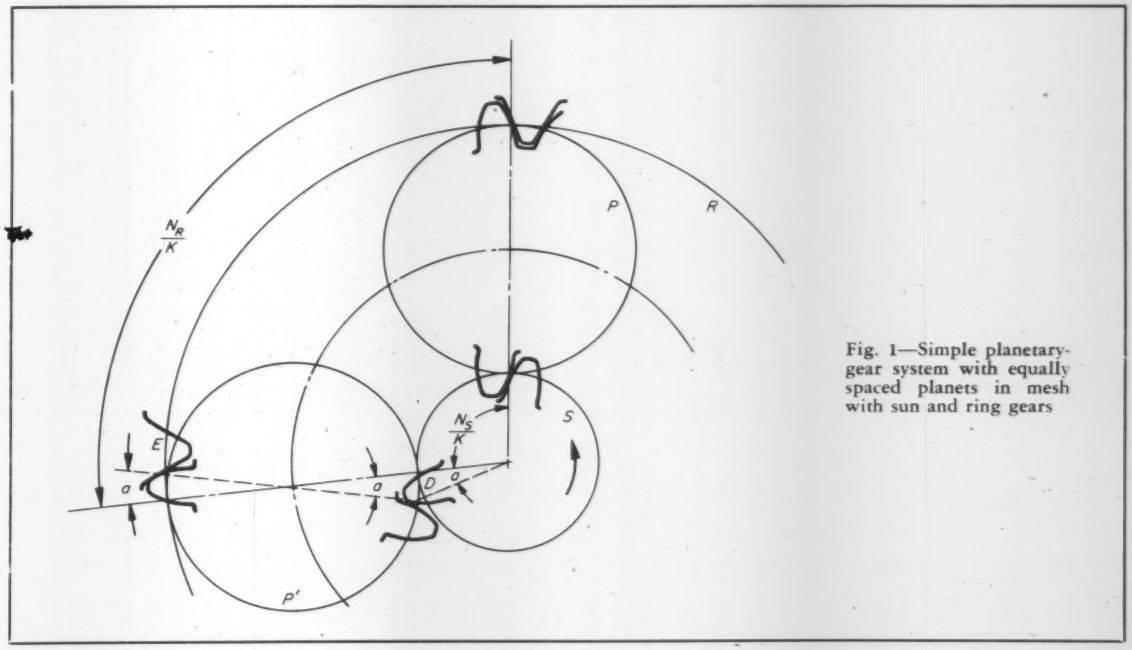

Fig. 1—Simple planetary-gear system with equally spaced planets in mesh with sun and ring gears

Table 1—Speed Ratios for Simple Planetary Gears

Driving Elements	Fixed Member	Driven Elements
Sun n_S [CW]	Ring $n_R = 0$	Cage and Planet $n_C = \frac{N_S}{N_R + N_S} n_S$ [CW] $n_P = \frac{N_R}{N_P} n_C$ [CCW]
Sun and Cage n_S [CW] n_C [CCW]	. . .	Ring and Planet $n_R = \frac{N_S}{N_R} (n_S + n_C) + n_C$ [CCW] $n_P = \frac{N_S}{N_P} (n_S + n_C)$ [CCW]
Sun and Cage n_S [CW] n_C [CW]	. . .	Ring and Planet $n_R = \frac{N_S}{N_R} (n_C - n_S) + n_C$ [CW if +] $n_P = \frac{N_S}{N_P} (n_C - n_S)$ [CW if +]
Sun and Ring n_S [CW] n_R [CW]	. . .	Cage and Planet $n_C = \frac{N_R}{N_R + N_S} n_R + \frac{N_S}{N_R + N_S} n_S$ [CW] $n_P = \frac{N_R}{N_P} (n_R - n_C)$ [CW if +]
Sun and Ring n_S [CW] n_R [CCW]	. . .	Cage and Planet $n_C = \frac{N_S}{N_R + N_S} n_S - \frac{N_R}{N_R + N_S} n_R$ [CW if +] $n_P = \frac{N_R}{N_P} (n_R + n_C)$ [CCW)
Ring n_R [CW]	Sun $n_S = 0$	Cage and Planet $n_C = \frac{N_R}{N_R + N_S} n_R$ [CW] $n_P = \frac{N_S}{N_P} n_C$ [CW]
Ring and Cage n_R [CW] n_C [CW]	. . .	Sun and Planet $n_S = \frac{N_R + N_S}{N_S} n_C - \frac{N_R}{N_S} n_R$ [CW if +] $n_P = \frac{N_R}{N_P} (n_R - n_C)$ [CW if +]
Ring and Cage n_R [CW] n_C [CCW]	. . .	Sun and Planet $n_S = \frac{N_R + N_S}{N_S} n_C + \frac{N_R}{N_S} n_R$ [CCW] $n_P = \frac{N_R}{N_P} (n_R + n_C)$ [CW]
Cage n_C [CW]	Ring $n_R = 0$	Sun and Planet $n_S = \frac{N_R + N_S}{N_S} n_C$ [CW] $n_P = \frac{N_R}{N_P} n_C$ [CCW]
Cage n_C [CW]	Sun $n_S = 0$	Ring and Planet $n_R = \frac{N_R + N_S}{N_R} n_C$ [CW] $n_P = \frac{N_S}{N_P} n_C$ [CW]

Example: Assume a simple planetary system in which the sun pinion drives clockwise (*CW*) at $n_S = 5$ rpm, and the ring gear is fixed. Numbers of teeth are: $N_S = 40$, $N_P = 30$, and $N_R = 100$. Determine the speed and direction of rotation of the cage and planet. From the first entry in Table 1, speed of cage is calculated: $n_C = N_S n_S/(N_R + N_S) = 40(5)/(100 + 40) = 1.43$ rpm clockwise. With this value, the speed of the planet is determined: $n_P = N_R n_C/N_P = 100(1.43)/30 = 4.76$ rpm counterclockwise (*CCW*).

Thereby, a feeling will be acquired for physical happenings. Also, extending the analysis to more complex gearing will be easier.

The recommended procedure for determining speed ratio is to list the known linear speeds, to compute the resulting linear speeds of the other parts, and to convert the linear speed into rotative speed. The ratio of speeds can then be easily computed.

For example, the most common planetary drive has a driving sun pinion, an internal ring gear fixed against rotation, and planets which mesh with the sun pinion and the ring gear. These planets are mounted in a planet carrier which acts as the output drive. Two linear velocities can be quickly found. The pitch-line speed of the input sun pinion is proportional to the input speed in rpm multiplied by the pitch radius, pitch diameter, or the number of teeth. Any one of these factors can be used if kept consistent throughout the analysis. And, of course, the pitch-line speed of the ring gear is zero.

When instantaneous velocities are considered, a simple diagram shows that the rigid body which connects the ring gear and the sun pinion is the planet gear, and that its center is midway between these two bodies. Therefore, its center moves tangentially at the mean of its extreme speeds, or one-half the sun-pinion tangential speed. Since the linear speed of the planet center is the same as that of the planet carrier at that point, the rotative speed of the planet carrier is its linear speed divided by the radius of the planet carrier. Therefore, the planet carrier rotates at one-half the sun-pinion speed times the ratio of sun-pinion radius to center distance. By consistent substitution of the index numbers, the speed-reduction ratio can be written in terms of the number of teeth in the sun, planet, or ring gears.

For the design of planet bearings, the rotative speed of the planet gear must be determined. Two different values for this speed can be obtained. The first is found by noting that, while the planet carrier moves the center of the planet gear around a complete circle, each tooth of the planet gear meshes with the ring gear, and the total number of meshing planet-gear teeth equals the number of ring-gear teeth.

Therefore, the planet gear rotates about its axis once for each carrier revolution times the ratio of the number of ring-gear teeth to the number of planet teeth. The second possible answer is of academic consequence. It is the number of revolutions observed by someone well out of the plane of rotation, and is always one less than the answer

Nomenclature

a = Fraction of one tooth pitch
I = Integral number
K = Number of planets
N = Number of teeth
n = Speed, rpm
Planetary components are identified as follows:
C = Cage
P = Planet
P_1 = Sun-mesh planet gear
R = Ring-mesh planet pinion
S = Ring gear
P_2 = Sun pinion

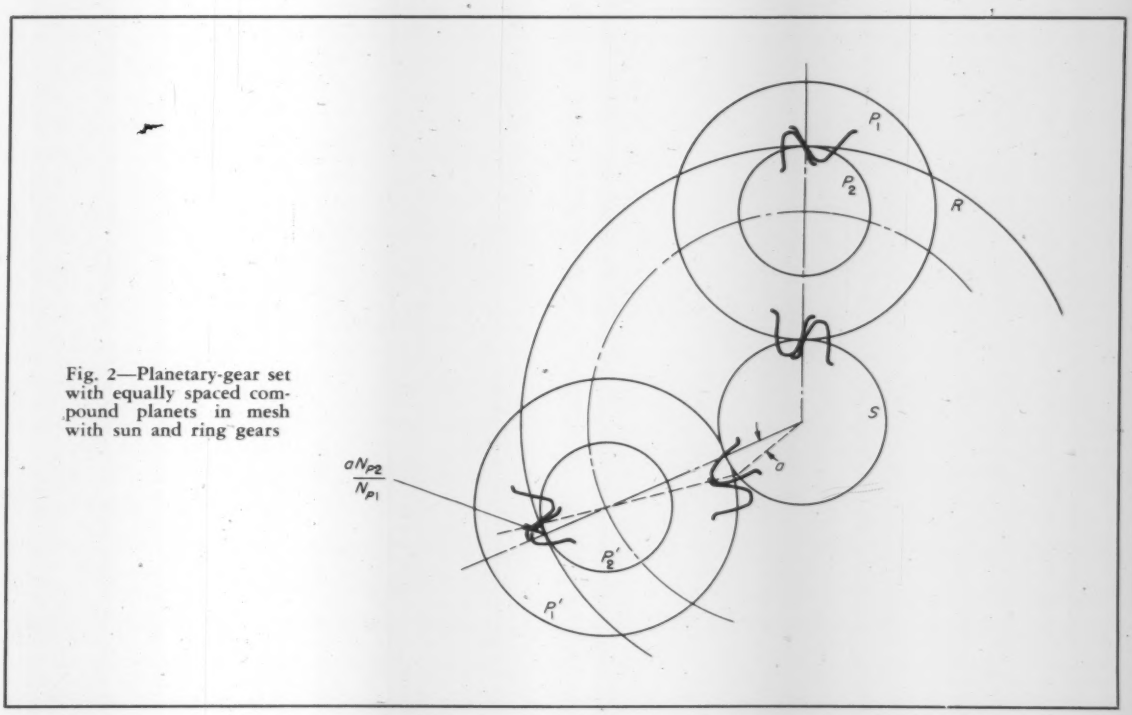

Fig. 2—Planetary-gear set with equally spaced compound planets in mesh with sun and ring gears

Table 2—Speed Ratios for Compound Planetary Gears

Driving Elements	Fixed Member	Driven Elements
Sun n_S [CW]	Ring $n_R = 0$	Cage and Planet $n_C = \frac{N_{P2} N_S}{N_{P2} N_S + N_{P1} N_R} n_S$ [CW] $n_P = \frac{N_R}{N_{P2}} n_C$ [CCW]
Sun and Cage n_S [CW] n_C [CCW]	. . .	Ring and Planet $n_R = \frac{N_{P2} N_S}{N_{P1} N_R} (n_S + n_C) + n_C$ [CCW] $n_P = \frac{N_S}{N_{P1}} (n_C + n_S)$ [CCW]
Sun and Cage n_S [CW] n_C [CW]	. . .	Ring and Planet $n_R = \frac{N_{P2} N_S}{N_{P1} N_R} (n_C - n_S) + n_C$ [CW if +] $n_P = \frac{N_S}{N_{P1}} (n_C - n_S)$ [CW if +]
Sun and Ring n_S [CW] n_R [CW]	. . .	Cage and Planet $n_C = \frac{N_{P2} N_S n_S + N_{P1} N_R n_R}{N_{P2} N_S + N_{P1} N_R}$ [CW] $n_P = \frac{N_S}{N_{P1}} (n_C - n_S)$ [CW if +]
Sun and Ring n_S [CW] n_R [CCW]	. . .	Cage and Planet $n_C = \frac{N_{P2} N_S n_S - N_{P1} N_R n_R}{N_{P2} N_S + N_{P1} N_R}$ [CW if +] $n_P = \frac{N_R N_S}{N_{P2} N_S + N_{P1} N_R} (n_R + n_S)$ [CCW]
Ring n_R [CW]	Sun $n_S = 0$	Cage and Planet $n_C = \frac{N_{P1} N_R}{N_{P2} N_S + N_{P1} N_R} n_R$ [CW] $n_P = \frac{N_S}{N_{P1}} n_C$ [CW]
Ring and Cage n_R [CW] n_C [CW]	. . .	Sun and Planet $n_S = \frac{N_{P1} N_R}{N_{P2} N_S} (n_C - n_R) + n_C$ [CW if +] $n_P = \frac{N_R N_S}{N_{P2} N_S + N_{P1} N_R} (n_R - n_S)$ [CW if +]
Ring and Cage n_R [CW] n_C [CCW]	. . .	Sun and Planet $n_S = \frac{N_{P1} N_R}{N_{P2} N_S} (n_C + n_R) + n_C$ [CCW] $n_P = \frac{N_R N_S}{N_{P2} N_S + N_{P1} N_R} (n_R + n_S)$ [CW]
Cage n_C [CW]	Ring $n_R = 0$	Sun and Planet $n_S = \frac{N_{P2} N_S + N_{P1} N_R}{N_{P2} N_S} n_C$ [CW] $n_P = \frac{N_R}{N_{P2}} n_C$ [CCW]
Cage n_C [CW]	Sun $n_S = 0$	Ring and Planet $n_R = \frac{N_{P2} N_S + N_{P1} N_R}{N_{P1} N_R} n_C$ [CW] $n_P = \frac{N_S}{N_{P1}} n_C$ [CW]

Example: Assume a compound planetary system in which both sun pinion and cage drive clockwise (CW). Speed of the sun is $n_S = 5$ rpm and speed of cage is $n_C = 10$ rpm. Numbers of teeth are: $N_S = 27$, $N_{P1} = 15$, $N_{P2} = 12$ and $N_R = 57$. Determine the speed and direction of rotation of the planet and ring gear. From the third entry in Table 2, speed of the planet is calculated: $n_P = N_S(n_C - n_S)/N_{P1} = 27(10 - 5)/15 = 9$ rpm clockwise. The speed of the ring gear is determined: $n_R = [N_{P2} N_S(n_C - n_S)/N_{P1} N_R] + n_C = [12(27)(10 - 5)/15(57)] + 10 = 11.9$ rpm clockwise.

obtained in the first method.

All of the speed ratios in Tables 1 and 2 are worked out in a similar manner. Note that relative directions must be listed carefully, since velocity is used here as a vector. For compound planetaries, the central velocity is not the mean value of the two extreme velocities, but is modified by the ratio of the planet pinion radius to the planet-gear radius.

Hence, the speed ratio for a particular part becomes equal to the rotational input speed divided by the rotational speed of the part in question. The fact that the ring gear drives instead of the sun pinion, or that two members simultaneously drive

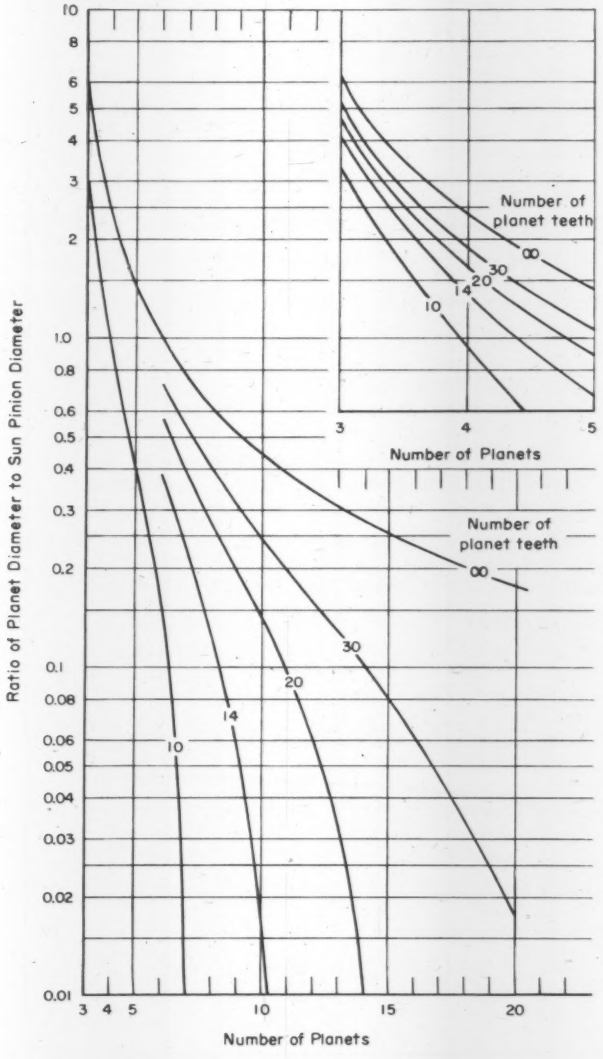
Ratio of Planet Diameter to Sun Pinion Diameter
Number of Planets
Number of planet teeth
∞
30
20
14
10
3 4 5
10 15 20
0.01 0.02 0.03 0.04 0.05 0.06 0.08 0.1 0.2 0.3 0.4 0.5 0.6 0.8 1.0 2 3 4 5 6 8 10

Fig. 3—Preliminary design chart for relating number of planet teeth, number of planets, and diameters of sun pinion and planet. Planets are assumed to be of equal size and are equally spaced around the sun pinion, with a tip clearance between planets of one tooth depth. For example, when the ratio of planet diameter to sun diameter is 0.38 and each planet has 20 teeth; not more than seven planets can be used.

the third, does not alter the approach. Although it is not truly planetary, the case of the fixed-planet carrier can be included in the analysis as a check point. The "planets" act only as idlers.

Assembly: It is all too easy to design a planetary-gear set so that no more than one planet gear can be mounted and meshed at a time. Since two and usually three planets are used to share the load and to balance reactions in a planetary system, it is worthwhile to investigate and understand this phenomenon in the design stage rather than to come upon it in assembly.

For equally spaced planets, the analysis is geometrical and can be followed from Fig. 1. Since number of teeth on the sun pinion (see Nomenclature) between the center line of first planet gear P and tooth D nearest the centerline of second planet gear P' must be integral,

$$\frac{N_S}{K} + a = I_S$$

where a is a fraction of one tooth pitch.

On the ring gear, tooth E on the diameter of planet gear P' corresponds to and is opposite sun pinion tooth D. Therefore,

$$\frac{N_R}{K} - a = I_R$$

Since both conditions exist simultaneously, the equations are added:

$$\frac{N_S}{K} + a + \frac{N_R}{K} - a = I$$

or

$$N_S + N_R = K(I_S + I_R) = KI$$

Thus, for simple planetary gears, the numerical rule for assembly states that the sum of the teeth in the ring gear and sun pinion must be an integral multiple of the number of planets.

This approach applies to compound as well as simple planetary-gear assemblies. Thus, the tooth-pitch equations between teeth in consecutive inner and outer meshes, Fig. 2, can be written. Since the inner and outer pitches need not be the same, the inner mesh equation is

$$\frac{N_S}{K} + a = I_S$$

and the outer mesh equation is

$$\frac{N_R}{K} - \frac{aN_{P2}}{N_{P1}} = I_R$$

Adding these equations and simplifying,

$$N_{P2}\,N_S + N_{P1}\,N_R = KI$$

Since the number of teeth in the planet gear and planet pinion operate on the number of teeth in the ring gear and sun pinion, respectively the sum of these products must contain the number of planets as a factor.

Maximum Number of Planets: Frequently the

problem is to select a gear to fit within a limited envelope and to carry rated torque without excessive tooth-loads. Such problems often lead to this question: Should one more planet be added to reduce the load per planet mesh? For instance, if three planets are marginally loaded, the use of four would reduce the average load to 75 per cent of its original value.

Two factors should be considered. First, three equally spaced planets have the advantage of optimum load distribution, characterized by the three-legged milk stool. Also, a carrier with three planets can adjust better to eccentric lineup, if free to move, than a planet carrier with four or five gears. There are, however, countless examples of working planetary-gear trains with more than three planet gears.

The second factor to be considered when an additional planet is to be added is that its weight and cost are proportionately lower than the increased load capacity it provides, if all planets are loaded.

The number of equal-sized, equally-spaced gears which can be spaced around a central pinion are shown in Fig. 3. These values result from a comparison of the length of the sides of regular polygons with the diameters of planet gears centered on the vertices of the polygons. The upper limit of the data, Fig. 3, represents cases in which the planets contain an infinite number of teeth. This condition would exist when the pitch circles became tangent to one another, and would not be practical for this application. Below this upper limit are other values computed for different diametral pitches and numbers of teeth in the central gear. The arbitrary tip clearance between planets is held constant at one whole depth.

Hunting-Tooth Combination: When two gears in mesh contain teeth in such numbers that there is no common numerical factor between them, each tooth on the smaller member will engage each tooth on the larger member. Such a combination is said to have a *hunting tooth,* since each pinion tooth meshes with or hunts through all the other gear teeth before re-engaging with its original mate. Although the characteristics of gear pairs with hunting teeth cannot be completely correlated to those of gear pairs which have some fairly high common factor, there are several differences which are apparent.

When a small nick or burr on one tooth rubs against every tooth in the mating gear, the nick or burr will probably be removed without distress. Such a process is called *running in,* and is most effective when the hunting-tooth combination is used. If, however, a tooth in a hunting-tooth pair becomes badly damaged, it could proceed to knock out every mating tooth in a few revolutions. Under such conditions, a set of nonhunting-tooth gears would give some degree of warning.

Tooth ratios can also be selected on a compromise basis. If a hunting-tooth combination is desired for some special reason but is inconvenient to acquire, a fair substitute is to use a gear pair with a low common factor such as 2 or 3. These comparisons apply to gear combinations in general and are not limited to planetary systems.

Nonsynchronous-Tooth Combination: Since all gear teeth have some degree of error in spacing, profile, or helix, it is possible that a steady input speed could be converted to a pulsating output speed, probably at tooth-mesh frequency. In important long-life applications, such as aircraft propeller drives, speed pulsation is dangerous because it induces fatigue. Pulsation can be greatly reduced if all planet gears are in different phases of tooth en-

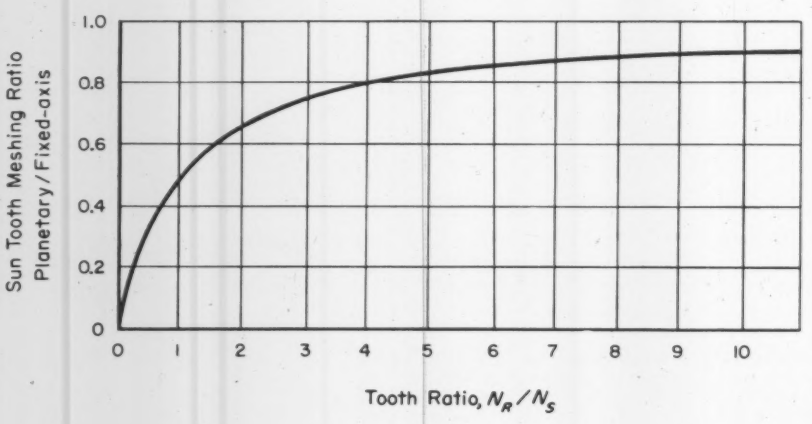

Fig. 4—Meshing ratio of sun teeth found from chart when ring/sun tooth ratio is known. Meshing ratio compares the number of sun meshes in a planetary system to the number in a fixed-axis system. As an example, a sun pinion has 20 teeth, and the ratio of the number of teeth in the ring gear to the number of teeth in the sun gear is four. From the chart, when 20 sun teeth pass a point on the center line, only (0.8) (20) or 16 sun teeth mesh with the planet

gagement with the sun pinion and ring gear.

A set of three planets can be used to illustrate this point. If a sun-pinion tooth at 0 deg is beginning to engage a tooth on planet 1, the tooth nearest the 120-deg position should be near pitch-line contact with planet 2, and the tooth nearest the 240-deg location should be leaving engagement with planet 3. To be nonsynchronous, a three-planet set must be so designed that the number of teeth in the sun pinion is not a multiple of three. Similarly, the number of ring-gear teeth should not be divisable by the number of planets.

If the mesh disturbances were sudden step inputs, this care would result in only one-third the disturbance force at three times the frequency. Effects of most gear-tooth errors are gradual, however, and with nonsynchronous design output disturbance is small.

Load Determinations: In this discussion of loads, only the tangential forces are considered. The tangential input force is figured from the input torque, pitch radius, and number of planets. The output torque can be computed from the speed ratio which, when multiplied by the transmission efficiency, becomes the torque ratio. Mechanical losses are considered to be negligible since the effects of friction do not appreciably upset the force and moment-balancing process.

For a simple planet, the driving force on the sun-pinion side equals the force imposed by the diametrically opposite ring gear. Both forces tend to move the planet center in the same direction as the sun periphery. Thus, a simple balance of moments and forces shows the driving force on the center of the planet is twice the tangential force on the sun pinion. As a check, this force can also be found by dividing the output torque by the product of the planet-carrier arm radius and the number of planets.

For compound planets, the central force on the planet is found by taking moments about the ring-gear mesh point. This force then equals the input force times its arm length (the planet-pinion radius plus planet-gear radius) divided by the distance to the planet center (the planet pinion radius). Other methods of applying torque can be analyzed in a similar manner.

Table 3—Load Cycle per Tooth for One Revolution of Sun Pinion

Component	Simple Planetary	Compound Planetary
Sun Pinion	$\frac{K N_R}{N_R + N_S}$	$\frac{K N_{P2} N_R}{N_{P1} N_R + N_{P2} N_S}$
Planet Gear	$\frac{N_R}{N_{P1}} \quad \frac{N_S}{N_R + N_S}$	$\frac{N_R}{N_{P1}} \quad \frac{N_{P2} N_S}{N_{P1} N_R + N_{P2} N_S}$
Planet Pinion	None used	$\frac{N_R}{N_{P2}} \quad \frac{N_{P2} N_S}{N_{P1} N_R + N_{P2} N_S}$
Fixed Ring Gear	$\frac{K N_S}{N_R + N_S}$	$\frac{K N_{P2} N_S}{N_{P1} N_R + N_{P2} N_S}$

Loading Cycles: For some applications, it is necessary to determine the number of engagements made by each tooth on any member. Although it is obvious, the analysis of a simple gear combination, such as a ring gear in mesh with a planet gear, will illustrate the general approach.

It can be seen from such an arrangement that each ring-gear tooth will mesh once with each planet during one revolution of the output shaft. Thus, for every minute of steady-state running, each ring-gear tooth is loaded once for each rpm of the output shaft times the number of planets.

When the planet is considered, each tooth will mesh once for each revolution about the planet axis, where the number of planet revolutions for each output revolution is N_R/N_P. If the planet is compounded, this rule applies to the planet pinion meshing with the ring gear. Thus, for one minute of operation, each planet tooth engages the ring-gear teeth N_R/N_P times the output speed in rpm.

The mesh situation with the sun pinion of a compound-planetary set is harder to visualize since both members are moving. It will be derived, beginning with the planet, in terms of a compound-planetary gear, to keep the derivation general.

The speed ratio for a compound-planetary gear is

$$\frac{N_{P1} N_R}{N_{P2} N_S} + 1$$

Thus, for each revolution of the sun pinion, the cage makes the following revolutions:

$$\frac{N_{P2} N_S}{N_{P1} N_R + N_{P2} N_S}$$

For each cage revolution, the planet pinion engages the ring gear $N_{P2}N_R/N_{P2}$ times. Therefore, the number of planet engagements with the ring gear becomes

$$\frac{N_{P2} N_R N_S}{N_{P1} N_R + N_{P2} N_S}$$

Similarly, for each planet-pinion tooth engagement, there are N_{P1}/N_{P2} planet-gear tooth engagements with the sun pinion, or $N_{P1} N_R N_S/(N_{P1} N_R + N_{P2} N_S)$.

For a simple planetary gear, $N_{P1} = N_{P2}$. Therefore, the number of planet engagements with the ring gear becomes $N_R N_S/(N_R + N_S)$. Table 3 summarizes the load cycles for individual members of the train.

It is interesting to note that the meshing frequency and tooth-load cycles are somewhat reduced from those experienced with fixed-axis gearing. For instance, the sun pinion would load each tooth K times per revolution if it meshed with K fixed-axis gears, but in a planetary drive each tooth meshes $K N_R/(N_R + N_S)$ times per revolution. Since this same coefficient applies to meshing velocity, dynamic effects are somewhat improved, Fig. 4.

IPG60 PRESSURE TRANSDUCERS

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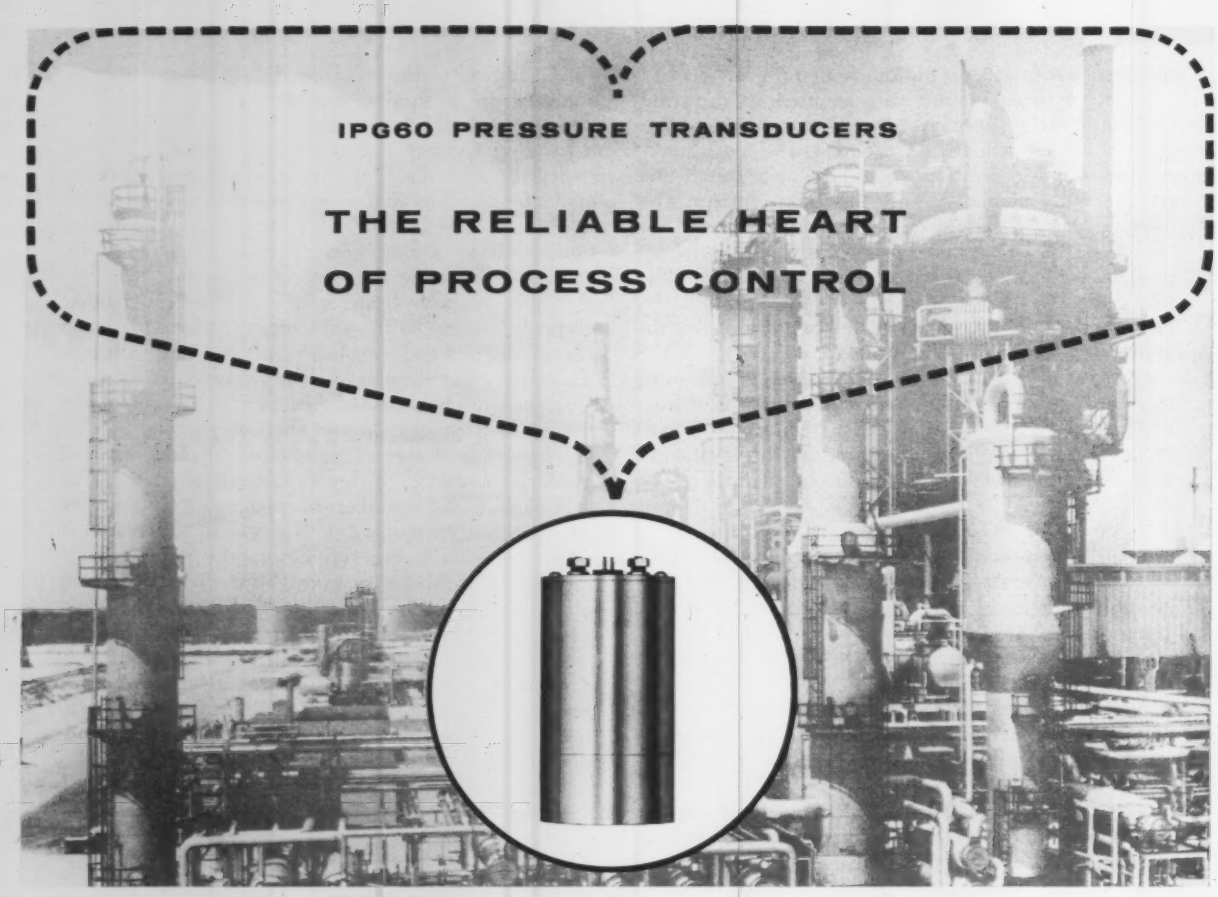

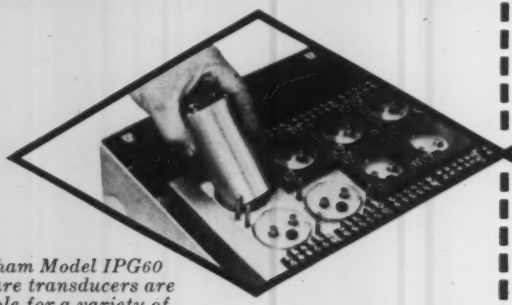

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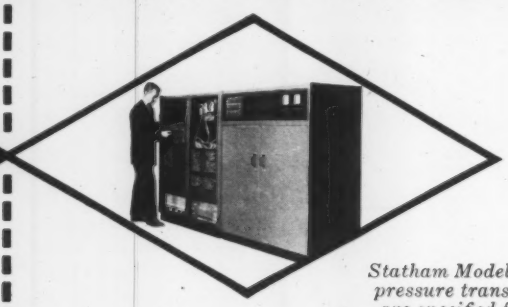

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PRESSURE MEDIA: Non-corrosive fluids

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RANGE: 0 to +15 psig.
NON-LINEARITY & HYSTERESIS: Not more than ±0.25% of full scale

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DESIGN ABSTRACTS

materials

Pyroceram

W. W. Shaver and S. D. Stookey, Corning Glass Works

A relatively new family of glass-ceramics is expected to find application in many fields because of increased mechanical strength at temperatures to 2200 F. Tailor-made compositions have high hardness and wear resistance, and a range of expansion coefficients to match various metals. Available shapes, heat treating and finishing methods, properties, and applications of these glass ceramics are covered.

SAE paper 60C, from SAE Summer Meeting, Atlantic City, N. J., June, 1958; 5 pp.

Space Age Materials

E. C. Bishop, Westinghouse Electric Corp.

A survey of possible structural applications of high-temperature alloys of tungsten, molybdenum, niobium, and chromium. Producibility methods, availability, refinement techniques, and formability of these alloys are discussed.

Westinghouse 22nd Annual Machine Tool Electrification Forum, Buffalo, April, 1958; 13 pp.

High-Temperature Properties Of Ductile Iron

R. D. Schelling and J. T. Eash, International Nickel Co. Inc.

This paper discusses effects of variations in phosphorus, copper, and molybdenum content and heat treatment on creep resistance of ferritic and pearlitic ductile iron at 800 F. Additional data on tensile strength, stress-rupture, and creep properties of a nickel-copper ductile iron at temperatures to 1000 F, and of a 20 to 35 per cent nickel austenitic ductile iron at temperatures to 1200 to 1400 F, are included.

ASTM Proceedings, Vol. 57, from ASTM Annual Meeting, Boston, June, 1958.

Delrin Acetal Resin, A New Engineering Material

H. H. Goodman and J. D. Young, E. I. Du Pont de Nemours & Co. Inc.

A discussion of properties and potential applications of a new acetal resin which will be commercially available by mid-1959. Fabrication techniques and methods of joining and finishing are covered.

SAE paper 60A, from SAE Summer Meeting, Atlantic City, N. J., June, 1958; 18 pp.

Conductive Ceramics

Z. A. Post and P. E. Ritt, Melpar Inc.

Descriptions of a representative selection of materials from the general class known as conductive ceramics. Materials include tin oxide, silicon carbide, and zirconium oxide. Physical, thermal, and electrical properties of each material and their applications are included.

IRE Transactions on Component Parts, *Vol. CP-5, No. 2, June, 1958; pp. 81-83.*

Thermal Conductivity of Aluminum Honeycomb Material

R. V. Duncle and J. T. Gier, University of California, and J. T. Bevans, Shell Development Corp.

Results of thermal-conductivity tests on a series of aluminum honeycomb panels. Thermal resistances are correlated in terms of honeycomb-cell geometry and type of adhesive bonding core and outer skin.

ASME Paper 58-SA-1, "The Thermal Conductivity of Aluminum Honeycomb Material Near Room Temperature," from 1958 Semiannual Meeting, Detroit, 7 pp.

mechanical

Vibration Instrumentation

A description of instruments used in vibration measurement including seismic-type transducers, vibration meters, and oscillograph. Discussion covers types of vibration and application of pickups for displacement, velocity, and acceleration motions.

Instrumentation Newsletter, *April, 1958; 5 pp.*

Control Systems for Servomechanisms Feed Drives

C. K. Taft, The Warner & Swasey Co.

A discussion of systems which control load by means of a power actuator. Factors which govern selection of specific components are analyzed, and electric and hydraulic actuators are compared. Methods of system regulation are included.

Westinghouse 22nd Annual Machine Tool Electrification Forum, Buffalo, April, 1958; 11 pp.

Designing Control Consoles

Frank G. Boledovich, The Cross Co.

Evaluation of a pushbutton console for machine control. Design requirements of the console are analyzed according to machine functions. Optimum locations of

pushbuttons, lights, and other operator controls are described in a case history.

From "Designing Control Consoles to Aid Trouble Shooting of Transfer Machines," Westinghouse 22nd Annual Machine Tool Electrification Forum, Buffalo, April, 1958; 14 pp.

Analog-Computer Techniques In Control System Design

Ernest C. Goggio, Tammen and Denison Inc.

Examples showing the wide diversity of problems encountered in industry which lend themselves to computer analysis and solution. Problems have been selected which are typical of those encountered by a computation center operated by a design engineering organization.

From "Some Application of Analog-Computer Techniques to Control System Design," IRE Transactions on Industrial Electronics, PGIE-5, April, 1958; Page 70.

How to Replace Gears By Mechanisms (Linkages)

K. Hain and G. Marx, Braunschweig, Germany

A practical method is shown for designing four-bar mechanisms having a prescribed transmission ratio held within prescribed tolerances, for a limited range of motion. Such mechanisms may economically replace gears in many applications. Charts enable the designer to choose the mechanism having the best transmission angle possible.

ASME paper 58-SA-33, from Semiannual Meeting, Detroit, June, 1958; 5 pp.

electrical

General Aspects of Cooling Airborne Electronic Equipment

J. Kaye, M. I. T., and H. Y. Choi, Tufts University

A brief introduction and review of problems of protecting and cooling electronic equipment in present and future high-speed devices. Various types of cooling devices, fluid flow processes and techniques, and trends of future developments are discussed.

IRE Transactions on Aeronautical and Navigational Electronics, *Vol. ANE-5, No. 1; page 4.*

Characteristics of High-Power Silicon Transistors

H. W. Henkels and T. P. Nowalk, Westinghouse Electric Corp.

A review of the characteristics of a new series of high-power silicon transistors having low internal dissipation and high power-handling capacities. Transistors are expected to find new applications in industry. Included are power ratings, design, voltage ratings, and saturation resistance.

Westinghouse 22nd Annual Machine Tool Electrification Forum, Buffalo, April, 1958; 12 pp.

A Classification System For Measurement and Control

Ernest A. Keller, Panellit Inc.

A new approach for the classification of instruments for measurement and control. This classification serves the engineer in selecting compatible instruments to solve specific problems of measurement or control. A card system permits a suitable instrument to be selected on the basis of establishing a performance parameter for a specific problem.

IRE Transactions on Industrial Electronics, *PGIE-6, May, 1958, Page 38.*

techniques

Methods of Joining Polyethylene Sheet

E. Rottner, Farbewerke Hoechst AG

Techniques of hot-air welding used in the fabrication of rigid polyvinyl chloride are not easily adaptable to fabrication of high-density polyethylene. However, satisfactory butt welding with heated tools can be accomplished readily. This method of joining, the apparatus required, and typical applications are covered. Also included are suggested shop layouts for economical processing of welded parts.

SPE paper 32, "Practical Methods of Fabricating Articles from High Density Polyethylene Sheet," from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 10 pp.

Large Section Injection Molding

M. Silovich, Ewart Products Co.

Large sections molded from plastic materials offer advantages to a designer not possible with alternate methods of fabrication. Integrated design and dimensional stability are two of the chief advantages inherent in large, molded parts. A series of case histories illustrates economies, design techniques, and production tips for large-section molding.

SPE paper 16, from Proceedings of the 14th Annual National Technical Conference, Detroit, January, 1958; 9 pp.

Design for Production By Welding

J. Mikulak, Worthington Corp.

A comprehensive coverage of design fundamentals which shows the proper approach to fabrication by welding. Limitations and economic capabilities of equipment and processes, and correct product geometry are covered. Welded components are considered from an appearance standpoint, and importance of the bending operations stressed.

AWS National Spring Meeting, St. Louis, April, 1958; 16 pp.

management

Engineer Retention

J. D. Staley, American Management Assoc.

Views of the job-seeking engineer are presented to reveal the trends in manpower distribution. Cause and effect of "job hopping," and reasons for professional dissatisfaction are discussed. Actual case histories disclose what engineers are getting out of jobs—workwise and salarywise. Suggestions for fitting the engineer to the job and some motivation tactics are included.

ASME paper 58-SA-45, from 1958 Semiannual Meeting, Detroit; 7 pp.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

Westinghouse Electric Corp., Pittsburgh, Pa.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

IRE—The Institute of Radio Engineers, 1 East 79th St., New York 31, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 25 cents to members, 50 cents to nonmembers.

Instrumentation Newsletter—Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

SPE—Society of Plastics Engineers Inc., 34 East Putnam Ave., Greenwich, Conn.

AWS—American Welding Society Inc., 33 West 39th St., New York 18, N. Y.

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Condensed specifications and other information on Liquatite flexible, liquid-tight conduit are contained in illustrated mailer. Sizes range from $\frac{3}{8}$ to 4 in. in lengths up to 1500 ft. 2 pages. Electri-Flex Co., Roselle, Ill. J

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"Meet the Veco Thermistor" is the title of five-chapter series of folders which relate the growth and wide variety of present-day applications of these electronic devices. Circuit diagrams, tables, and charts serve to amplify the thermistor story. 4 pages each. Victory Engineering Corp., 536 Springfield Rd., Union, N. J. D

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Protection for large motors, pumps, compressors, and other rotating equipment is provided by the Model 65 Vibraswitch, subject of Bulletin RF-586. This malfunction detector responds to any mechanical failure, and it can sound an alarm or shut down the equipment before costly damage occurs. 4 pages. Robertshaw-Fulton Controls Co., Aeronautical & Instrument Div., Anaheim, Calif. L

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Chemical Milling

The design and production aspects of chemical milling are related for engineers in illustrated brochure entitled, "Chemical Milling." Answers to the questions of what is chemical milling, what are its advantages, what are the design factors, and where can it be used are given. 10 pages. United States Chemical Milling Corp., 1700 Rosecrans Ave., Manhattan Beach, Calif. L

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Easy to install and to remove, Sabeco split thrust bearings are made in $3\frac{1}{2}$ to 10-in. OD and $1\frac{3}{4}$ to 7-in. ID. Details of these bronze bearings are given in illustrated folder. 4 pages. Saginaw Bearing Co., 821 S. Water St., Saginaw, Mich. H

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Custom-Made Rods

Custom-made rods for ladder rungs, steps, scaffolds, milk crates, toy axles, stoves, electric motors, furniture, and hundreds of other products are subject of Bulletin BRL-2. Also detailed are standard cold formed fasteners and special parts. 4 pages. Brainard Rivet Co., Girard, Ohio. F

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Immersion Plating

"Immersion ('Electroless') Plating — What It Is and What It Can Do" is title of technical information bulletin on the electroplating of electronic, electro-mechanical, and aircraft components. Company can plate both precious and base metals. Pierce Precision Plating Co., Dept. A, 1040 Varian St., San Carlos, Calif. M

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Pipeline Compensators

Engineering and application data on Flexon expansion compensators for steam and hot water lines are given in Bulletin 163 R. Both 60 psi and 175 psi types are described. Sizes range to 2 and 3 in., respectively. 4 pages. Flexonics Corp., 1315 S. Third Ave., Maywood, Ill. J

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Suitable for sealing a wide range of fluids at pressures from vacuum to more than 5000 psi and at temperatures from −80 to 500° F, one-piece Still-Seal gaskets are leakproof static seals with full metal-to-metal contact. They are described in detail in illustrated catalog sheet. 20 pages. Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif. L

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Silicone Rubber for Tubing

Nomograph SF-1164 aids in the determination of the quantity of silicone rubber compound required for the production of tubing. Its use is applicable to any silicone rubber extrusion up to 14 in. in diameter with wall thicknesses from 40 to 150 mils. Union Carbide Corp., Silicones Div., 30 E. 42nd St., New York 17, N. Y. C

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Silicon Diode Packages

Single, multiple, 4, and 20-amp diode packages for airborne and industrial applications are subjects of four illustrated technical data sheets. Specifications and other information are covered. 2 pages each. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

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High Rate Tester

Features of the Model 625 B high rate tester described in illustrated bulletin include high loading rate, calibrated records, no shock transfer, remote control, and continuously variable deformation rate. Load ranges are 0 to 20 lb/min or 0 to 5000 lb maximum. Allegany Instrument Co., 1091 Wills Mountain, Cumberland, Md. C

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Electrical Connectors

Specifications, diagrams, and application information on the new Continental Series 250 connectors for electrical power use are contained in technical brochure. This series is available in 20, 34, 50, and 75 contacts, with optional polarizing screw locks, aluminum hoods, and protective shells. 6 pages. DeJur-Amsco Corp, Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y. D

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Test Benches

Rucker hydraulic and pneumatic test benches for checking all types of equipment and components are described concisely in illustrated bulletin. Portable and stationary models are available. 4 pages. Rucker Co., 4700 San Pablo Ave., Oakland, Calif. M

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Furnished in capacities from 2 to 50 gpm, and for pressures up to 400 psi, 61 different models of bronze, positive displacement pumps are described in Catalog 109. These pumps were developed for marine use, but they are applicable for lubrication, hydraulic power transmission, liquid transfer, and other industrial services. 4 pages. Tuthill Pump Co., 953 E. 95th St., Chicago 19, Ill. J

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Sensational Blitzhacker gets its edge from

SHARON STAINLESS

Here's something new in food choppers. It cuts its way through more food faster than you can pronounce its name—*Blitzhacker.*

One of the more amazing things about the Blitzhacker is its blade, an accordion of Sharon Stainless Steel with a cutting edge *shaved* on. A special shaving process develops a durable edge that will stay sharp years on end without chipping.

When you have a problem or an idea where Stainless Steel could be involved, call the Sharon office nearest you for service.

SHARONSTEEL

SHARON STEEL CORP.

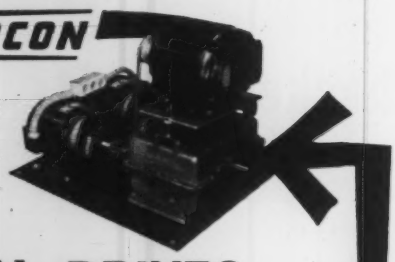
SHARON, PENNSYLVANIA

CHICAGO • CINCINNATI • CLEVELAND • DAYTON • DETROIT • GRAND RAPIDS • INDIANAPOLIS • LOS ANGELES • MILWAUKEE
NEW YORK • PHILADELPHIA • ROCHESTER • SHARON • SEATTLE • SAN FRANCISCO • WASHINGTON, D. C. • TORONTO • MONTREAL

Circle 464 on Page 19

SPECON

FULLY REVERSING ELECTRICAL DIFFERENTIAL DRIVES



Full Rating, Full Torque at Zero Speeds • Fast Response • Low Drive Inertia • Zero Backlash

Electrical Differential Drives are part of the family of SPECON variable speed drives and differential transmissions designed and produced by Stratos. They utilize a motor-generator combination electrically coupled in a closed loop and mechanically coupled to a double differential gear box.

The entire output range, from 0 to max. r.p.m. is accomplished by operating the two DC machines at a maximum variation of 2:1.

These drives are suited for installations requiring fully reversing feature (EDD type) and for winding applications where a large build-up occurs (EDW type). For complete information, (including capacity charts and output speed regulation), on Electrical Drives, Mechanical Differential Transmissions, and Gear Boxes, write to:

SPECON Stratos Industrial Products Branch #42, Route 109, West Babylon, N.Y.

Turbo-Expanders and Compressors • Pneumatic Pressure Regulators • SPECON Variable Speed Drives and Transmissions

Circle 466 on Page 19

HYDRAULIC SERVO FUNDAMENTALS

Vol. I Theoretical and practical aspects of servo system design $1.00

Vol. II Servo components and their effect on system performance $1.00

Vol. III Determining transient response of servo systems $1.00

Order from

MACHINE DESIGN

Reader Service Department

Penton Bldg., Cleveland 13, Ohio

Remittance or Company Purchase Order must be included with order

HELPFUL LITERATURE

DC Supplies

Details of a line of Q-Nobatrons, transistorized low-voltage high-current direct current supplies with outputs of 6, 12, or 28 v at 15 or 30 w, are given in product data sheet. 2 pages. Sorenson & Co., Richards Avenue, South Norwalk, Conn. B

Circle 618 on Page 19

Chemical Feed Systems

Correct size for chemical feeding systems is readily determined with nomograph. Companion Data Sheet D-58 deals with application engineering information related to continuous cyanide and chrome wastes treatment systems. 4 pages each. Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 619 on Page 19

Insulation Tubing

Sample board contains actual samples of various Turbo plastic and coated insulation tubings for electrical and electronic equipment. Specifications, operating temperatures, available sizes, colors, and other data are given for each. William Brand & Co., Willimantic, Conn. B

Circle 620 on Page 19

Hydraulic Cylinders

Line of space-saving, square head Super Duty hydraulic cylinders for "extra tough" applications is detailed in illustrated Bulletin 1258. Rated 3000-5000 psi, they have tapered cushions for gradual deceleration and minimum "cushion entrance" shock. Bore sizes are 2 to 12 in. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio. G

Circle 621 on Page 19

Nonferrous Casting

Facilities and services offered for production of small and medium size nonferrous castings in job lot and mass production quantities are outlined in illustrated folder. Production consists of brass, bronze, nickel-silver, lead, copper, and aluminum alloys. 4 pages. Non-Ferrous Casting Co., 736 Albany St., Dayton 8, Ohio. G

Circle 622 on Page 19

Solid Film Lubricant

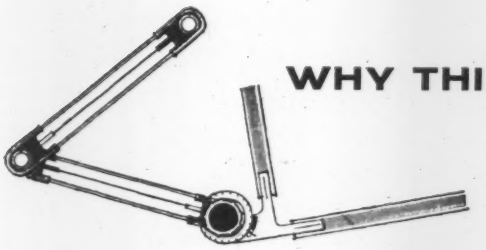
Surf-Kote M-1284 matrix-bonded, solid, dry film lubricant which contains molybdenum disulfide is subject of Bulletin SL-121. Metallic bonding increases its number of uses. Product is suited for extreme pressures and temperatures and unusual atmospheres. 4 pages. Hohman Plating & Mfg. Co., 814 Vermont Ave., Dayton 4, Ohio. G

Circle 623 on Page 19

Flanged Bearing Block

Specifications and list prices relative to unbreakable malleable two-bolt flanged bearing blocks are given in Bulletin Supplement BU-101-A. It covers the FB210 Series in 16 stock shaft sizes from ½ to 1-7/16 in. Browning Mfg. Co., Maysville, Ky. G

Circle 624 on Page 19



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

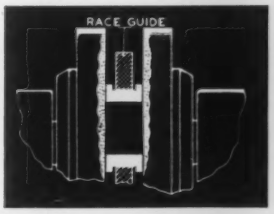
SCRUPULOUS CONTROL OF FINISHING OPERATIONS ASSURES SUPERIOR INNER RACES

The function of a bearing inner race is to provide a fatigue-resistant surface between shaft and rollers. Because of the smaller area of contact between inner race and rollers, as opposed to outer race and rollers, there is a heavier load on the inner race.

Because of this concentrated load, *the inner race is the critical member of any roller bearing*, from the fatigue life standpoint.

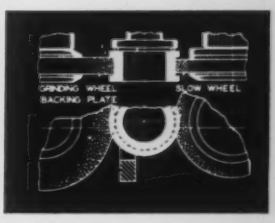
To assure the finest possible inner races, and therefore smoother, longer performance, HYATT exercises scrupulous control over the four critical finishing operations detailed at the right. It's another good reason why so many designers prefer HYATTS.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer.
Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey, Pittsburgh, Detroit, Chicago and Oakland, California.



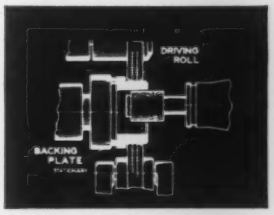
1 DOUBLE END GRIND

Grinding sequence is important. Ends are first faced off *square and parallel* to serve as accurate reference during later work. Hyatt double end grind provides excellent control of parallelism.



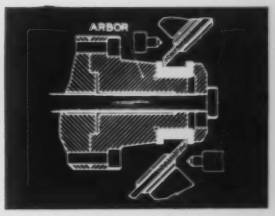
2 CENTERLESS PATHWAY GRIND

This Hyatt-pioneered process holds taper and out-of-round to minimum, produces as nearly perfect cylinder as commercially practical. Backing plate against ground end insures accuracy.



3 CHUCKLESS BORE GRIND

Here again, the centerless process assures a bore concentric with pathway, with minimum wall variation, by removing stock from high spots passing between drive roll and grinding wheel.



4 FLANGE GRINDING

To assure that they will run true with roller pathway, all flange faces are also ground using squared ends for reference. This provides vital even contact with ends of rollers.

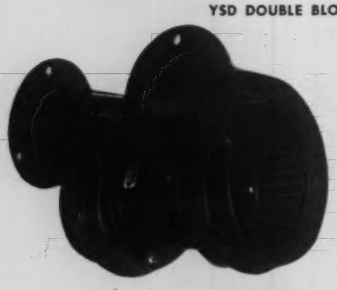
THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958 GM FORWARD FROM FIFTY

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

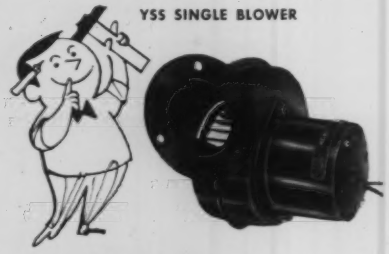
put HEINZE in your designs

YSD DOUBLE BLOWER



YS BLOWERS

YSS SINGLE BLOWER



MINIMIZE AIR NOISE

ASSURE LONG BEARING LIFE

Large (3⅝ in.) balanced air rotors, powered by a slow-speed 4 pole shaded pole induction motor, assure quiet operation and long bearing life. Blowers are enclosed in durable metal housing. YSS Single Blower delivers 50 cfm at 1650 rpm; YSD Double Blower delivers 100 cfm. Standard units operate on 115V, AC, 60 cycle. Other voltages and frequencies are available.

Applications include photographic dark rooms; laboratories; cooling of electronic tubes; kitchens; refrigeration and air conditioning units; vending machines; and similar uses.

Send coupon for technical data on the complete line of Heinze Sub-Fractional Horsepower Motors and Blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

Heinze Electric Company, Dep't D
685 Lawrence St., Lowell, Mass.

Please send me technical literature and price information on Heinze Motors and Blowers.

Name & Title_____

Company_____

Street & No._____

City & State_____

Circle 468 on Page 19

HELPFUL LITERATURE

Voltage Regulators

Standard instantaneous electronic automatic voltage regulators, rated from 0.25 to 10 kva for nominal 115 or 230 v output, and adjustable from 110 to 120 v or 220 to 240 v, are described in illustrated Stabiline Bulletin S358IE. Ratings, dimensions, and features are given. 12 pages. Superior Electric Co., Bristol, Conn. B

Circle 625 on Page 19

Teflon Terminals

Condensed listing of popular Press-Fit Teflon terminals, such as stand-offs, feedthroughs, connectors, test jacks, probes, plugs and taper-pin receptacles, is presented in catalog. Insertion procedures, a cross-index of press-fit numbers and corresponding insertion tools are included. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y. D

Circle 626 on Page 19

Pipe Connections

Pipe connections, unions, vessel closures and bleeder valves are covered as to methods of construction, specifications and prices in Grayloc catalog. Connections are applicable for pressures up to 15,000 psi. 12 pages. Gray Tool Co., Box 2291, Houston, Tex. O

Circle 627 on Page 19

Iron Powder

Specifications of Easton RZ iron powders for powder metallurgy, electronics, flame cutting, scarfing and washing, flux coating of welding electrodes, and chemical applications are provided in data folder. 6 pages. Easton Metal Powder Co., 900 Line St., Easton, Pa. E

Circle 628 on Page 19

Repeat Cycle Dial Timer

The ATC miniature Atcotrol Duo-Set repeat cycle dial timer controls two independently adjusted load circuits for on-off cycling. Bulletin N-80 gives mounting dimensions, schematic and wiring diagrams, standard dials, and electrical ratings. 4 pages. Automatic Timing & Controls, Inc., Dept. 202, King of Prussia, Pa. E

Circle 629 on Page 19

Tank Weighing Systems

Equipment used with Emery load cells to provide indication, recording, printing and control in tank weighing installations is shown in Bulletin 581. Featured is a study of the Emery rolling-ball head, a device to offset damaging results of cross loads. 12 pages. A. H. Emery Co., Pine St., New Canaan, Conn. B

Circle 630 on Page 19

Miniature Servo Motor

Model M-100 60-cycle miniature servo motor reaches full speed of 1460 rpm in 4/1000th second. Electrical and mechanical data, performance, and features are pointed up in bulletin. Dynamic Instrument Corp., 59 New York Ave., Westbury, L. I., N. Y. D

Circle 631 on Page 19

enflex HAS THE ANSWER TO YOUR FLEXIBLE TUBING PROBLEMS

It's "Flexineering" — the technical help of Penflex engineers on your specific design, application and installation *plus* the "know how" to supply just the right flexible tubing for your need.

If you want to convey air, water, steam, gases, volatiles; granular, abrasive or light solid materials . . . or require flexible connections that "give" with vibration, expansion, contraction, come to Penflex. Its complete line of bronze, galvanized and stainless steel, corrugated and interlocked tubing is rugged . . . safe at high pressures and temperatures, free from metal fatigue. All types, all sizes in ⅛" to 24" I.D.

GET YOUR COPY

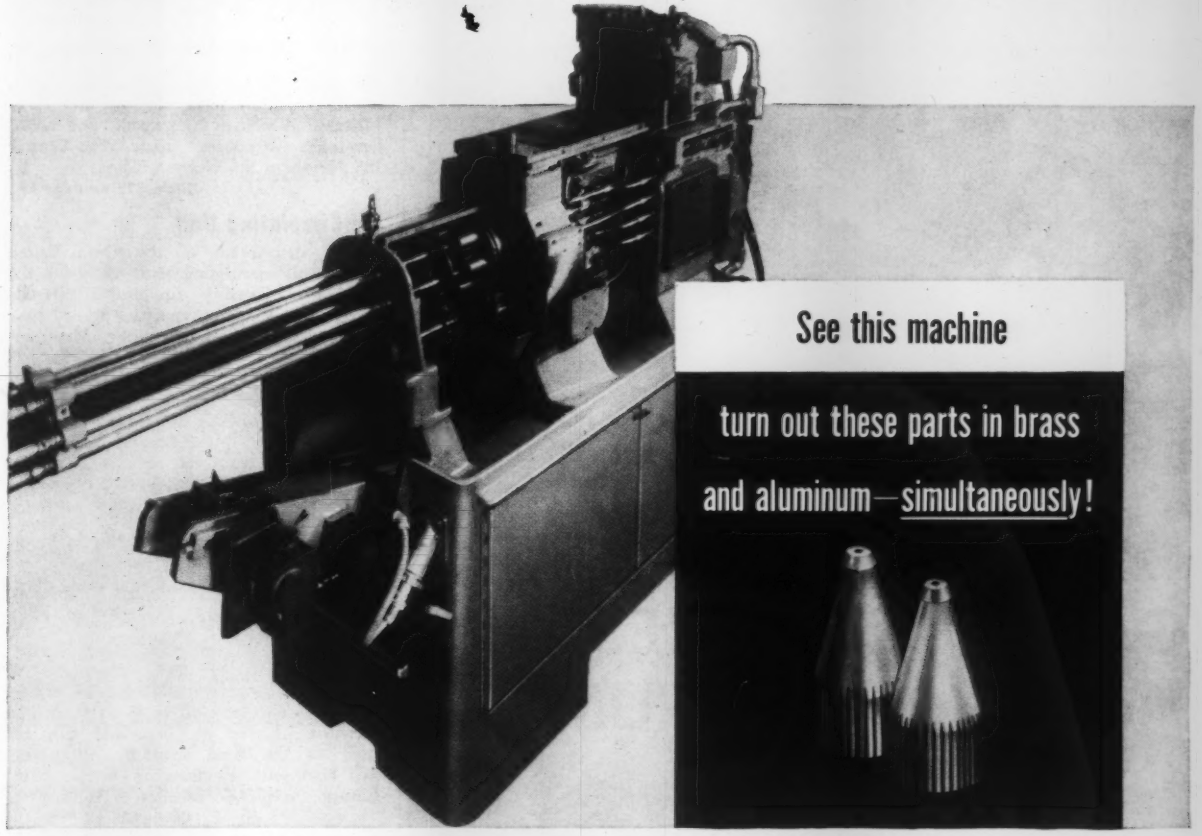
Write Pennsylvania Flexible Metallic Tubing Company, Inc. 7239 Powers Lane, Phila. 42, for "Flexineering" helpful book on tubing.

PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

Circle 469 on Page 19

BETTER MACHINING STARTS WITH ALCOA SCREW MACHINE STOCK

Alcoa proved it in Cleveland . . . now will prove it in other cities



See screw machine parts produced in aluminum at less cost than steel or brass

When Alcoa and National Acme Company sponsored a machining demonstration in Cleveland last September, 700 design and production engineers and purchasing people saw aluminum and brass parts produced *simultaneously* on a six-spindle automatic screw machine—saw documented evidence that screw machine parts can be produced cheaper in aluminum than in brass or steel. Many expressed frank amazement at the cost comparisons shown.

Here is eye-opening machining news for all industry. Now *you* can see this demonstration, which Alcoa will sponsor in Chicago, Boston, New York, Los Angeles* and other important centers.

If your function is design or production of products that use screw machine parts, you will find the Alcoa machining demonstration an enlightening experience. You will see how aluminum offers the ultimate in design freedom because it's so workable, so easy to machine—because it gives better finishes including anodized color. You will see the new color movie about Alcoa Screw Machine Stock, "The Four Amazing Alloys."

Send in the coupon for your invitation—and for a Design Calculator (slip-stick) for use with Alcoa® Aluminum Screw Machine Stock.

Look for this label . . . it's your guide to the best in aluminum value

ALCOA ALUMINUM

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

*September 17, 18—Alcoa's Vernon Works
5151 Alcoa Avenue, Vernon, California

Aluminum Company of America
873-H Alcoa Building, Pittsburgh 19, Pennsylvania

Yes, I want to attend the Alcoa machining demonstration nearest my area _____.

Please send my invitation—and Design Calculator.

Name _____

Position _____

Company _____

Address _____

City _____ Zone _____ State _____

Circle 470 on Page 19

"Choose from this wide range of Gast Air Compressors", says C. E. Bradley, Ass't. Sales Mgr. "Vacuum Pumps are also available in corresponding models."

Here's high performance . . . in a full line of

GAST rotary vane COMPRESSORS and VACUUM PUMPS

When you select original equipment Air Pumps, look at the Gast Line. You'll see how your product—and budget—may benefit.

Within a well-defined range, Gast Pumps excel on hundreds of product applications. (Capacities .6 to 45 cfm.; pressures to 30 psi., vacuum to 28 in. Hg.) Precision-built primarily for O.E.M. use, they are rugged and dependable. Simple rotary-vane design maintains like-new performance for years, because vanes take up their own wear automatically. Air displacement is positive and pulseless—no air tank needed. Ball bearings and self-adjusting shaft seals keep efficiency high.

Types include: Dual-chamber (one chamber for vacuum, one for pressure), integral-motor pumps, light-duty models for moderate pressure or vacuum, and fan-cooled models for heavy-duty service. Oil-less (carbon-vane) types provide absolutely oil-free air if desired.

Submit your problem for suggestions by Gast Engineers—or . . .

Write today for Catalog on Compressors or Vacuum Pumps. State specific type or capacity that interests you.

(1) *(Front to rear) Dual Chamber Pumps:*	(2) *Integral-Motor Pumps for O.E.M. or Lab use:*	(3) *Light-Duty Models Moderate Vac./Press.*	(4) *Heavy-Duty Models, with Fan Cooling, V-belt or Direct Dr.*
Model 11 x 1740, total to 23 cfm.	0521, 1/3 hp. to 3.8 cfm.	3040, up to 24.2 cfm.	2565, to 21.0 cfm.
10 x 1040, to 18 cfm.	0321, 1/4 hp. to 2.2 cfm.	1550, up to 15.0 cfm.	1065, to 8.3 cfm.
Single (In Hand) AD-440, to .6 cfm.	0211, 1/6 hp. to 1.3 cfm.	0740, up to 5.6 cfm.	0465, to 4.0 cfm.
	0406, 1/12 hp. to .6 cfm.	0440, up to 4.0 cfm.	4565, to 45.0 cfm.
		0240, up to 2.0 cfm.	

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

HELPFUL LITERATURE

Continuous Strip Terminals

Catalog data relative to continuous strip electrical terminals and attaching machines are presented in Bulletin K1958. Terminals include snap-on male and female types in both straight and flag varieties, as well as ring, spade, and hook terminals. 16 pages. Kent Mfg. Corp., 188 Needham St., Newton, Mass. B

Circle 632 on Page 19

Oil Circulating Unit

Brief description of the Dura Circ-Oilator oil circulating unit is given in Form 484. Rated ½ hp, unit is offered in ½ and 1½ gpm capacities at 250 psi. Durametallic Corp., Kalamazoo, Mich. H

Circle 633 on Page 19

Worm Gear Drives

Illustrated Bulletin 150 provides useful information on worm gearing in general, points out advantages of this type of gearing and gives design and manufacturing facts. Capacities range from fractional to over 460 hp. 8 pages. Cleveland Worm & Gear Co., 3249 E. 80th St., Cleveland 4, Ohio. F

Circle 634 on Page 19

Hydraulic Pumps

Series 10-500 air-operated hydraulic pumps described in folder are available in nine sizes for producing 500 to 25,000 psi hydraulic pressure from 100 psi air pressure. Either oil or water can be used as the fluid medium. 6 pages. SC Hydraulic Engineering Corp., 6318 Central Ave., Los Angeles 1, Calif. L

Circle 635 on Page 19

Photography in Engineering

"Photography Serves Engineering" is title of Bulletin A-6114 which shows how Cronaflex engineering reproduction films can expedite design and reduce the need for repetitive work by skilled engineering personnel. 4 pages. E. I. du Pont de Nemours & Co., Photo Products Div., Wilmington 98, Del. C

Circle 636 on Page 19

Electric Heating Units

Advantages, design details, and specifications are given in Bulletin 158 on a complete line of flat, semicylindrical, and immersion type electric heating elements for use in machines and equipmnt. 4 pages. Hevi-Duty Electric Co., Milwaukee 1, Wis. K

Circle 637 on Page 19

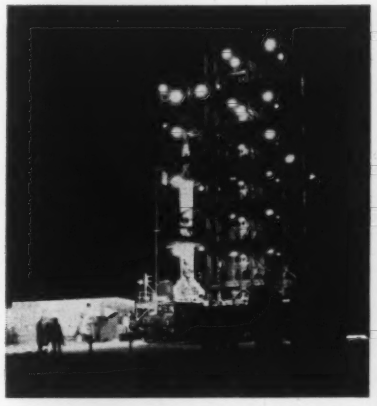
Research Facilities

A complete summary of the projects, facilities, services, and capabilities of this company is presented in illustrated brochure. More than 2000 skilled personnel are engaged in this division, with 500 on the scientific and engineering staffs and more than 50 consultants on special projects. The entire range of scientific and industrial research and development is covered. 28 pages. Avco Mfg. Co., Research & Advanced Development Div., 20 S. Union St., Lawrence, Mass. B

Circle 638 on Page 19

PRODUCT-DESIGN MEMOS FROM DUREZ

Insulative molding compounds | **Corrosion-resistant polyester** **Low-cost control knobs**



Official U. S. Navy photo

But what if it rains?

From time immemorial, weather has upset the military plans of men. In colonial days, wet gunpowder could lose a skirmish. Today, one moisture-affected part can nullify months of costly labor on a new missile.

This helps to explain the increasing pressure on moisture-resistant insulations for electronic parts that must not fail. It explains, too, the growing interest in a relatively new Durez molding material, *diallyl phthalate.*

This is the *only* plastic that retains its high insulation values over extended periods at relative humidities above 90%.

Its arc resistance, as measured by ASTM D495 (Method A or B), can be consistently reproduced.

It does not corrode metal contact points.

Because it is a thermosetting material, it provides virtual freedom from cold flow and creep.

You can get this material from us as an orlon-filled granular blue or green molding compound with plasticity values of 10, 12, or 16 by ASTM D731. It is designed to meet the requirements of Mil-M-18794, Type SDI-5.

For a data sheet detailing properties of the compound, and of molded material, check the coupon.

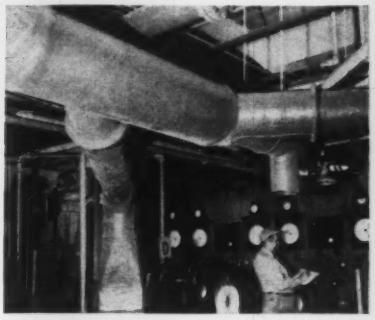
Hetron® ducts outlast metal

Perhaps you've been thinking of Hetron mainly as a *fire-retardant* polyester material.

It's true you get outstanding fire retardance with Hetron. But don't overlook its *corrosion resistance,* which is equally impressive in equipment such as this glass-reinforced ductwork manufactured by duVerre, Inc.

Venting corrosive fumes from a chemical reactor, aluminum ducts failed in 11 months. Ducts made of Hetron 92 replaced them—and have gone 17 months without a sign of deterioration.

In another plant, Hetron 92 replaces rubber-lined steel ductwork which lasted

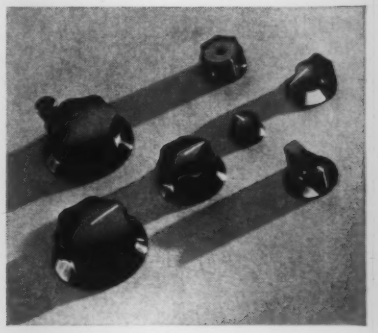


duVerre, Inc.

less than a year under the corrosive bite of wet chlorine. The Hetron ductwork, in service four years, has required no maintenance and is as sound as the day it was installed.

Because it is self-extinguishing, you can safely specify Hetron in many places where a conventional polyester won't do. Fire retardance is *inherent*—does not depend on additives that might dilute corrosion resistance.

Are you taking full advantage of Hetron's unique qualities? A check mark on the coupon will bring you an illustrated bulletin outlining properties and uses of the versatile Hetron resin family.



Ready-tooled knobs

Why tool up for a standard item like a control knob, when you can buy general-purpose knobs like these—probably at a good saving?

Many custom molders can supply knobs in Durez phenolic, from stock tooling, to fit most standard mountings. You can have them hot-stamped with numbers or characters; equipped with special motifs.

Styled as a family, they blend smoothly with modern equipment lines; wipe clean without dulling; and stand up to heat, dampness, and corrosive atmospheres. For further information, consult your molder.

For more information on Durez materials mentioned above, check here:

- ☐ Diallyl phthalate, Durez 16694
- ☐ Hetron polyester resins (bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
508 Walck Road, North Tonawanda, N. Y.

Circle 472 on Page 19

ALL NEW!

Veeder-Root
Panel-Mounted High Speed
Electrical Counters

...with electric resetting in 1/10th of a second

These new Series 1591 Electrical Counters fill the gap between standard and electronic counters for industrial, data processing, or laboratory and scientific uses. They're designed for accuracy and long life at very high speeds (rated at 3000 counts per minute, with extended test-runs up to 6000 cpm).

And they have the unmatched convenience of *instant push-button resetting*, either mechanically right on the machine . . . or electrically from a distance. Panel-groups of these counters can be placed right in your office . . . *and one button can reset an entire panel*. Counters feature large figures, small size, low-wattage coils for continuous duty and other V-R vantage points on which patents are pending.

These new and different counters are the latest evidence that Veeder-Root design and development always keep pace with modern counting requirements. Write for specifications and prices.

Added Evidence that Everyone Can Count on

VEEDER-ROOT
INCORPORATED
HARTFORD 2, CONNECTICUT
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Constant Delay Lines

Custom-built and standard constant delay lines with impedances ranging from 500 to 10,000 ohms, and delays from 0.1 to 36 microseconds are described in illustrated bulletin. Various configurations are shown for standard and printed circuit mounting methods. Control Electronics Co., 1925 New York Ave., Huntington Station, L. I., N. Y. D

Circle 639 on Page 19

Magnetic Amplifier

The Model 410 Summing Amplifier is a 400-cycle magnetic amplifier for use in signal mixing and summing. Both performance and application data are presented in bulletin. 2 pages. Acromag, Inc., 22519 Telegraph Rd., Detroit 41, Mich. H

Circle 640 on Page 19

Flow Meters

Designed for pressures up to 5000 psi and flow rates to 3000 gpm, Ar-Met rotameters will effectively measure and control fluid flow rate. Complete design and performance data are given on these instruments in Bulletin 130. 8 pages. Brooks Rotameter Co., Box 432, Lansdale, Pa. E

Circle 641 on Page 19

Pressure Switch

Details of Electroset pressure switches which self-adjust to close at an applied pressure when a solenoid circuit is momentarily energized are given in Bulletin 1570. 4 pages. Trans-Sonics., Inc., Burlington, Mass. B

Circle 642 on Page 19

Power Steering Unit

Though primarily designed as a power steering mechanism for heavy construction and agricultural vehicles, the 2000 Series rotary type hydraulic servo mechanism described in illustrated bulletin is also applicable wherever a rotary servo motion is needed. 4 pages. Behlen Mfg. Co., Columbus, Nebr. I

Circle 643 on Page 19

Molded Products

"We Mold and Fabricate Rubber and Synthetics with Imagination" is apt title of folder which describes company's facilities, shows typical custom-molded parts, and lists properties of natural and synthetic rubbers. 6 pages. Mechanical Rubber Products Co., 35 Vail Rd., Warwick, N. Y. D

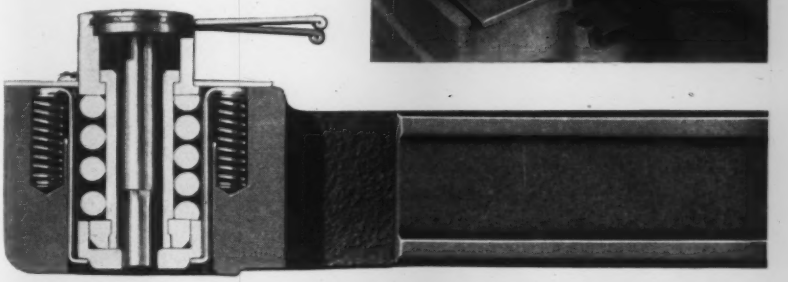
Circle 644 on Page 19

Solenoid Valves

Low-cost Type M and G bronze solenoid valves are available in 3/8 to 3-in. sizes for pressures to 400 psi. Also described in Bulletin 500 C are stainless steel valves in 1/2 to 2-in. sizes and the Type HV valves with four independent controls for variable opening and closing speeds, flow control, and manual opening. 4 pages. J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind. J

Circle 645 on Page 19

Strippit Punching and Notching Units are easily mounted to templates, T-slotted plates or rails in unlimited patterns for long press runs or quick-change pilot runs. Complete range of standard tools, or "specials" made up on request.



fits your design—
keeps costs in line!

STRIPPIT multiple
punching and notching

THE ABOVE CUTAWAY of a Strippit Punching Unit — one of a wide selection for flats, structurals and extrusions up to 3/4" mild steel — illustrates the extreme flexibility, high production and economy of the Strippit system.

NOTE THAT each unit is complete with punch, die button, stripping guide, guide button, lifter assembly and retainers — all quickly interchangeable in a husky holder and actuated by the press ram. Multiple punching — and notching — press setups are easily bench-assembled on drilled mounting templates, with each unit accurately located by the pilot pin in its base. Press down-time is almost negligible in setups of Strippit Punching Units, Notching Units, Punch and Die Assemblies or combinations of all three.

Write today for full details and if you wish, a demonstration on your work at your plant by a Strippit mobile unit.

Warehouse stocks in Chicago and Los Angeles.

A UNIT OF HOUDAILLE INDUSTRIES, INC.

WALES STRIPPIT COMPANY

216 Buell Road, Akron, New York

Manufactured in Canada by Strippit Tool and Machine Limited, Brampton, Ontario

Circle 474 on Page 19

GRADE A ACCURACY... PREMIUM GAUGE CONSTRUCTION AT THE PRICE OF GENERAL PURPOSE GAUGES...

Now you can buy hydraulic pressure gauges that are sturdier, more accurate, and have the specific quality features you need . . . yet cost you no more than you'd pay for general purpose gauges. These 5090 Series gauges are part of the new USG "A" Line, specifically designed to withstand the frequent shocks, pulsations, and mechanical vibrations—such as found in the operation of hydraulic presses, Diesel or oil field equipment, and the like.

MEET A.S.A. GRADE A STANDARDS—Available in sizes from 3½ to 12 inches, for pressures up to 10,000 psi, these gauges are guaranteed accurate within 1% of scale range for middle (working) half of scale—1½% for remainder.

EXTRA RUGGED CONSTRUCTION—For the severe service conditions found in hydraulic pressure measurements, the 5090 Series gauges embody such design points as:

a **Top quality, 403 stainless steel Bourdon tubes,** produced and quality-controlled in USG's own plant—your assurance of long, dependable service.

b **Extended life of movement,** through wide meshing gears, even under most severe conditions of pulsation and continuous service.

c **Protection from shock on movement,** through spring-loaded link, when pointer returns to zero with sudden release of pressure.

d **Sustained accuracy, reproducibility, and ease of maintenance** through use of USG's patented ARC-LOC movement (stainless steel pinion, nylon-faced stainless steel segment, and deep stainless steel bushings mounted in stainless steel plates.)

Find Your Nearest Distributor in The 'Yellow Pages'

PRICE, IT'S LOW!—You'll have to see the new Series 5090 gauge to believe that it's available without a premium price. Ask your U. S. Gauge distributor for a demonstration today, or write for a copy of new Catalog 305 which describes USG's complete line of industrial gauges.

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

USG

Circle 475 on Page 19

Flexible Couplings

Design and application information on the newly-designed Series GC continuous-sleeve flexible couplings is contained in Bulletin 502. These compact, lightweight, efficient units are available in capacities from 5 to 705 hp at 100 rpm. 4 pages. Zurn Industries, Inc., Mechanical Power Transmission Div., Erie, Pa. F

Circle 646 on Page 19

Miniature Motors & Reducers

Four basic models and sizes of miniature, direct current, permanent magnet and wound field motors, as well as spur and planetary gear boxes, governors, and radio noise filters are covered in condensed catalog. 10 pages. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 647 on Page 19

Electrical Devices

Specifications, illustrations, prices, and use data on extensive line of conduit fittings, cable terminators, cast iron boxes, solderless and power connectors, grounding devices, and interlocked armor cable fittings are found in Price Catalog 140. 96 pages. O. Z. Electrical Mfg. Co., 262 Bond St., Brooklyn 17, N. Y. D

Circle 648 on Page 19

Speed Reducers

Illustrated Folder B-1 shows the many forms of Optimount helical geared Reductors, Ratiomotors, and Flanged Reductors available from stock. Input and output rpm, motor horsepower, mounting options, design features are covered. 8 pages. Boston Gear Works, Quincy 71, Mass. B

Circle 649 on Page 19

Expansion Joints

Ratings of S-R expansion joints subjected to axial or lateral movement, angular rotation, or combinations of these movements are presented in catalog. Detailed data on 3 to 72-in. diameter joints are given. 80 pages. Badger Mfg. Co., 230 Bent St., Cambridge, Mass. B

Circle 650 on Page 19

Laminated Plastics

Technical data on molded Formica laminated plastics are contained in illustrated Form 685. The various grades available, information required for quotation, standard shapes, and other details are given. Insert design is covered. 8 pages. Formica Corp., Cincinnati 32, Ohio. G

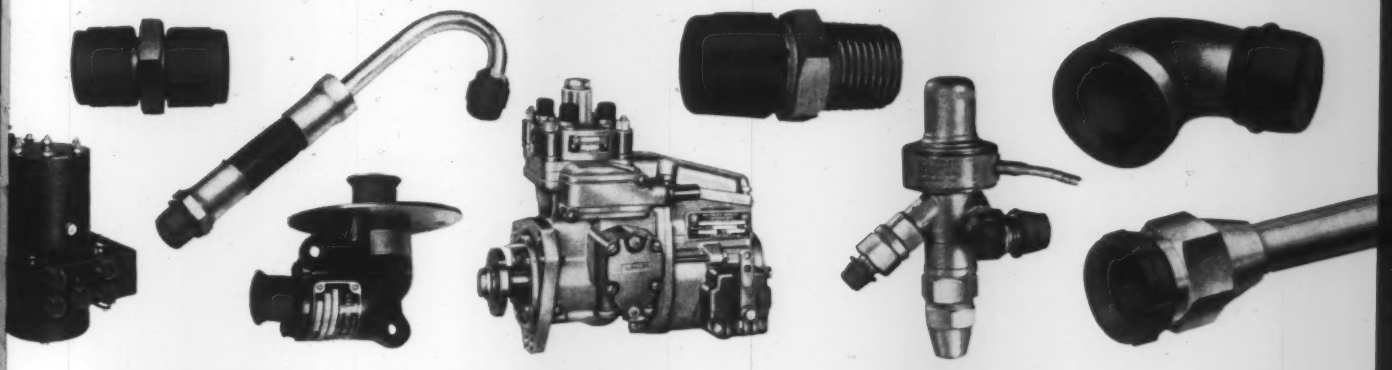
Circle 651 on Page 19

High Vacuum Valves

Dimensional diagrams, technical data, and complete specifications on VG Series of high vacuum valves are found on Data Sheets VG-4 and VG-5. Prices for each type of 1, 2, 4, and 6-in. gate valve and controls for them are found on Price List V-3. 2 pages each. Vacuum Research Co., 420 Market St., San Francisco 11, Calif. M

Circle 652 on Page 19

Caplugs protect nearly everything under the sun...in process, storage and transit...



prevent damage to threads and delicate parts...keep out dirt and moisture...

made of tough, flexible polyethylene...won't chip, break, shred or collapse

Caplugs

10 standardized styles... over 500 sizes in stock

get a free handful of Caplugs in exchange for the attached coupon

Circle 476 on Page 19

CAPLUGS DIVISION, Protective Closures Co., Inc.
2201 Elmwood Avenue, Buffalo 23, N. Y.

MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

NAME _____

TITLE _____

FIRM _____

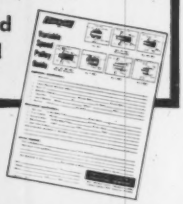
ADDRESS _____

CITY _____ ZONE _____ STATE _____

Take ALL the Problems Out of Your Variable Speed Requirements

Put Lovejoy's exclusive individualized service to work for you...a complete line of variable speed pulleys and transmissions—plus personalized engineering guidance to assure full satisfaction.

- Speed ratios: up to 10 to 1
- Horsepowers: fractional to 15
- Constant belt alignment
- Instant speed changes while equipment is running
- Easily installed on new or old equipment.



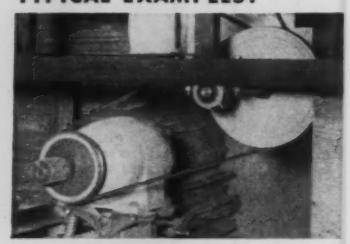
Here's how it works...

a simple and convenient two-step plan:

❶ Lovejoy sends you full information on the types of variable speed pulleys and transmissions available . . . along with a guide sheet to help you supply us with pertinent information on the type you need and the service you require.

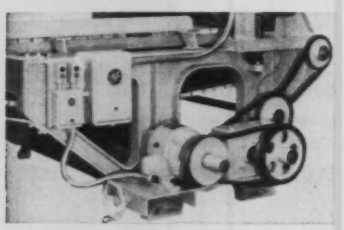
❷ Depending on your requirements, Lovejoy rushes recommendations, blue prints, suggested solutions to problems . . . or, if you desire, will send a representative to give you first-hand assistance. For standard or relatively simple applications, cost quotations can be furnished immediately.

TYPICAL EXAMPLES:

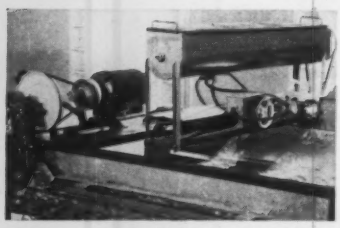


Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.

Type 135 Pulley meets all requirements on a vibrating machine.



Proper drive for a slat bed rip saw is provided by a Type 302 Pulley.



This Lovejoy "double" solved a grading machine problem—Type 145 Pulley and No. 2 Select-O-Speed.

Save time and expense. Get your Variable Speed Pulley Guide by requesting Form 118F today.

LOVEJOY FLEXIBLE COUPLING CO.

4818 WEST LAKE STREET • CHICAGO 44, ILLINOIS

HELPFUL LITERATURE

Electrical Enclosures

Wiring boxes, control panel enclosures, control consoles, pushbutton enclosures, wireway, and wiring troughs are described in pages of 1958 illustrated catalog. Products protect controls and wiring from dust, oil, and other liquids. Application data, engineering drawings, specifications, and a price list are inclded. 28 pages. Hoffman Engineering Corp., Anoka, Minn. J

Circle 653 on Page 19

Environmental Testing

Facilities of this company's Environmental Testing Div. are described and illustrated in a folder. Tests performed include temperature extremes, sand and dust, humidity, fungus, salt spray, shock, vibration, altitude, and explosion. 8 pages. Bowser-Morner Testing Laboratories, Inc., 141 Bruen St., Dayton 1, Ohio. G

Circle 654 on Page 19

High Vacuum Valves

Full-opening design of Series ST gate type high-vacuum valves, described in Data Sheet 571, assures a short straight-through unrestricted flow. Sizes range from 2 to 20 in. 2 pages. F. J. Stokes Corp., Vacuum Equipment Div., 5500 Tabor Rd., Philadelphia 20, Pa. E

Circle 655 on Page 19

Special Metal Stamping

Informational Folder 101 details the services of this company in fabrication and production of stampings from rare and specialized metals. Reference chart shows properties and typical uses for 20 different special metals. 4 pages. Send your request to Staver Co., 49-51 N. Saxon Ave., Bay Shore, N. Y. D

Rubber Making Facilities

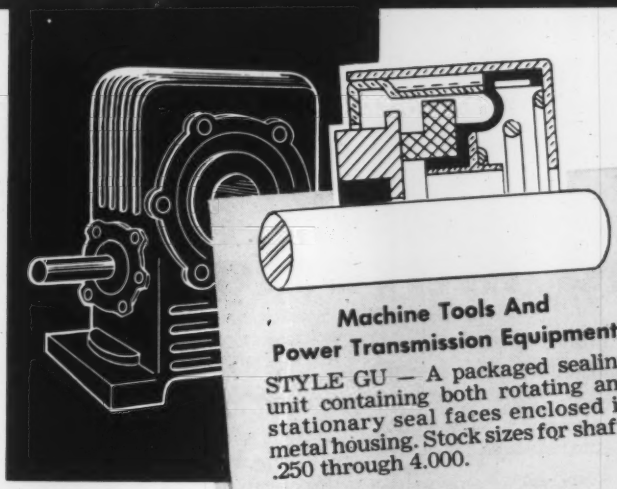
"Adventures in Rubberland" is four-color brochure which takes the reader on a trip through the rubber manufacturing plants of this company. It covers general offices, the Research and Development Div., and the black magic, silicone, plastic and latex, rainbow, and the engineering plants. 16 pages. Write directly to Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn. J

Miniature Switches

General-purpose, high sensitivity, immersionproof, metal-cased, reset, ac/dc, automatic-appliance, and AN-JAN miniature snap-acting switches are specified in Catalog-Digest 358. 4 pages. For a copy write to W. L. Maxson Corp., Unimax Switch Div., Ives Rd., Wallingford, Conn. B

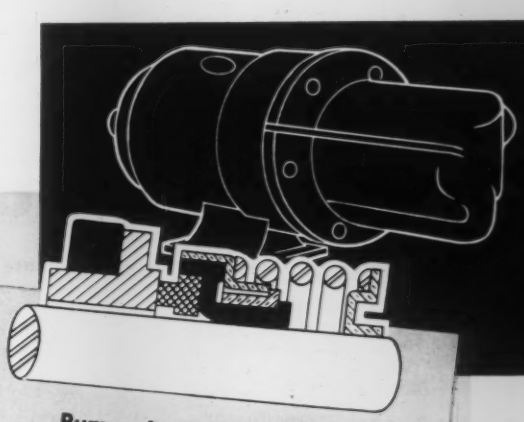
Waterproof Connectors

Pressurized and waterproof plugs and receptacles, plug and receptacle caps, waterproof cable clamps, high voltage receptacle and plug, connector assemblies, and tubing clamps are among items covered in Form AN-24-58. Specifications are tabulated. 24 pages. Request on company letterhead to H. H. Buggie, Inc., Box 817, Toledo 1, Ohio. G



Machine Tools And Power Transmission Equipment

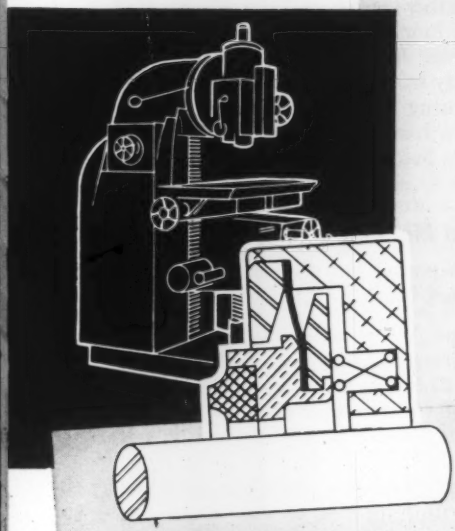
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

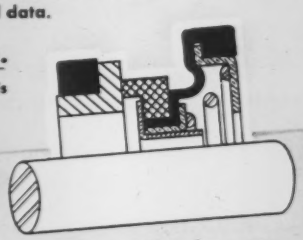
A Complete Line GITS SHAFT SEALS For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

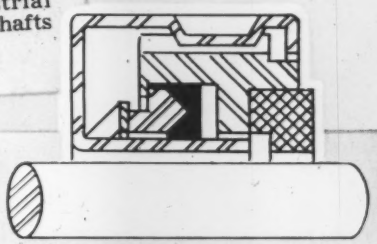
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



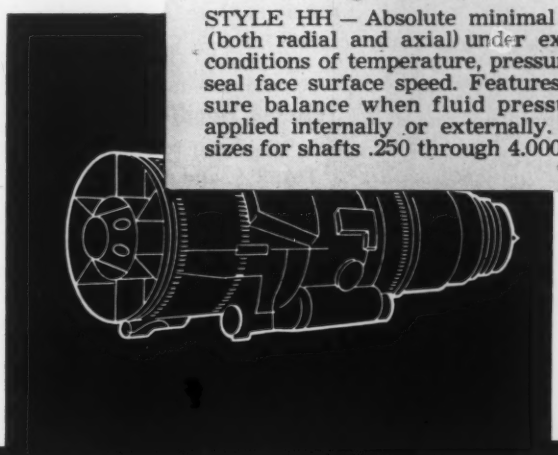
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 478 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Self-Insulating Fasteners

have metal shanks and plastic heads

Plastic-headed ferrous and nonferrous screws, studs, rivets, and nails provide mechanical-property advantages of metal and electrical-property advantages of plastic. Fasteners eliminate the need for separate insulation or insulating assemblies. Plastic heads prevent corrosion and moisture absorption in mechanical

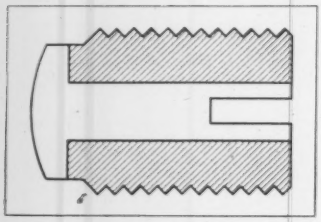
and electrical assemblies, since they provide effective sealing at critical points. They withstand impact, have good thermal insulating properties, and prevent galling when in contact with decorative or easily marred surface finishes. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y. D

Circle 656 on Page 19

Electrical Contacts

contain bonded core of contact material

Cor-Bond electrical contacts are made from rod stock containing a firmly bonded core of contact material such as fine silver, coin silver, gold, palladium, or a special alloy. Body material is usually free-machining yellow brass, although other materials can be used. Contacts are produced complete in one operation, with core upset and formed to make contact face. Operation hardens face and provides a smooth burnished surface. Almost any part that can be produced on a screw ma-



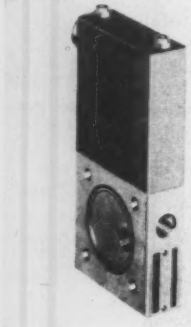
chine can be made into an electrical contact, including all types of screw contacts as well as special shapes for embedment into plastic supports. Small contact parts for miniature and subminiature relays and switches are easily produced. Contacts provide improved electrical bond, better thermal and electrical conductivity, and controlled contours. **Fansteel Metallurgical Corp.**, North Chicago, Ill. J

Circle 657 on Page 19

Solenoid Control Valve

is only 1 in. thick

Quick-As-Wink S-3C-S solenoid-operated valve can be used with air or oil at pressures to 125 psi and temperatures to 150 F. Unit is only 1 in. thick, 3 in. wide, and 6 1/16-in. high. It is available tapped for either $\frac{1}{8}$ or $\frac{1}{4}$-in. pipe connection, and is rated at 300 cycles per minute for continuous operation and up to 700 cycles per minute for intermittent service on air at 120 psig. Valve is available



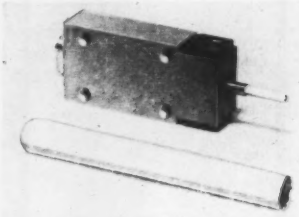
in normally closed or normally open three-way designs, or with four-way action. Valves can be manifolded together easily and quickly in any of four 90-deg positions. Eight valves can be operated simultaneously from a single air supply. Valve housing is milled from solid aluminum bar stock. **C. B. Hunt & Son Inc.**, Salem, Ohio. G

Circle 658 on Page 19

Flat Motor

is permanent-magnet, ball-bearing type

Type VS permanent-magnet, ball-bearing motor is only 7/16 in. thick by 27/32 in. wide by $1\frac{7}{8}$ in. long. Motor meets requirements of various MIL specifications on humidity, salt spray, shock, vibration, and fungus. Weighing only 1.7 oz, unit produces starting torques to 1.0 oz-in. and can be used in intermittent or con-



tinuous-duty applications. It is furnished with a variety of armature windings to accommodate system voltages from 3 to 50 v dc. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 659 on Page 19

Tapered Handles

in lengths of $\frac{7}{8}$, $1\frac{1}{4}$, $2\frac{1}{4}$, and 4 in.

Four tapered handles have applications ranging from machine tools to household utensils. They are available in both black phenolic (shown) or colored bakelite, and have female

New program timer features complete adjustability

In many applications, a timer has a "standard" job to do throughout its expected life, never requiring a change of timing sequence. But in many others, it's desirable to be able to change the timing sequence and the intervals making up the sequence in a complete cycle.

The new Cramer Type 511 and Type 521 Cycling Timers fill the bill for a unit combining high accuracy with complete field adjustability of as many as eight individual timed intervals. Although these timers can be supplied with preset cams to fit the needs of a present application, the added feature of adjustability makes them the ideal choice where the timing sequence may later be changed.

Operation

Applying power through an external sustained contact starts the timer, which continues to cycle until the control contact is broken. Full cycle time is the total time range of the timer specified, and may be selected from a large number of available ranges. If desired, the timer can be wired to perform one cycle and stop.

At the start of each cycle, the snap-acting SPDT load switches are in the initial positions specified (or established through adjustment) by the user. As the cycle progresses, each load switch is transferred by its operating cam to open or close its connected circuit at the required time and for the required duration.

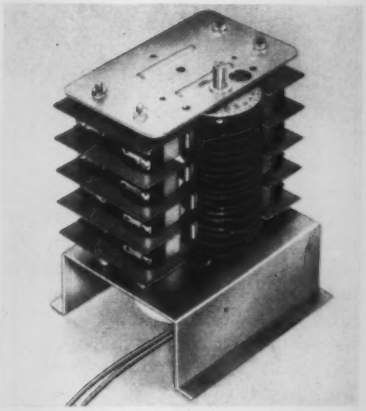
Timing Cam Adjustment

Each SPDT switch is operated by a double cam, one section to close the switch to one contact, the other to close it to the opposite contact. Depending on circuit wiring, either of these actions can "make" or "break" the load circuit. Each section of each cam is independently adjustable through a full 180°, without disturbing any other cam setting, by means of a small spanner wrench furnished with the unit. Adjustment is indicated on a dial which is marked in percent of total cycle time, permitting accurate selection of the desired "make" and "break" points for each load switch.

Features

TIME RANGES — From 1 cycle in 6 seconds to 1 cycle in 48 hours.

LOAD CIRCUITS — From 1 to 3 (Type 511) or from 4 to 8 (Type 521), each controlled by a totally-enclosed quick-make quick-break SPDT switch rated for 20 amperes at 125 or 250 volts AC (non-inductive).



Field-Adjustable Program Timer Type 521

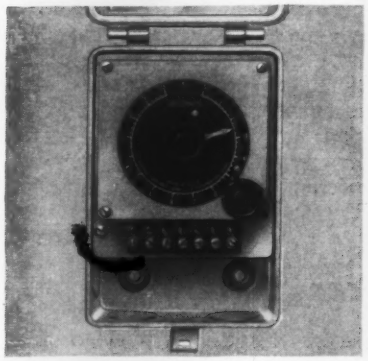
OPERATING TIME — Minimum operating time for each circuit is approximately 1/30 of total cycle time.

ACCURACY — At operating point of any one circuit, 1½°; between any two circuits, 3°.

MOTOR — Cramer high-torque synchronous, for 115 and 230 volts, 25, 50 and 60 cycles. Motors for operation on DC or at other frequencies are available in limited time ranges.

For detailed information and complete specifications, write Cramer Controls Corporation, Box 6, Centerbrook, Conn.

THREE MORE WAYS TO SOLVE YOUR TIMING PROBLEMS

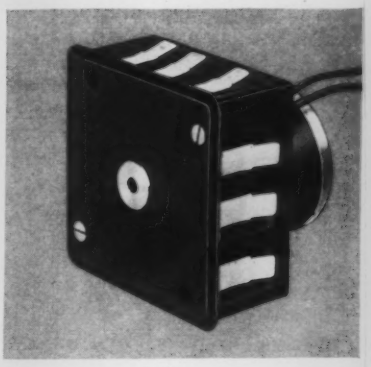


VARIABLE-CYCLE PULSE TIMER TYPE 650

Makes or breaks an electrical circuit for a fixed period or "pulse" of ½ second to 12½ hours, at continuously repeated intervals that are adjustable from ¾ second to 24 hours. By choice of load connection, control can be based either on the fixed pulse time or on the adjustable interval between pulses. Cycling period can easily be changed during operation.

ADJUSTABLE PERCENTAGE TIMER TYPE 610

Makes or breaks an electrical circuit for a variable percentage of a basic fixed cycle time. Desired percentage of total cycle time, for ON or OFF control of the timed device, is adjustable from 4% to 96% in steps of 1%. Total cycle-time ranges from 15 seconds to 24 hours. Internal connections can easily be arranged so that the load circuit is either closed or open for the indicated percentage of the full cycle.



CYCLING TIMER TYPE 571

Provides reliable and inexpensive control of repetitive switching for built-in applications. One through four poles, SPST or SPDT open-blade switches with contacts rated at 30 amperes, each controlled by a timing cam specially cut to user's requirements. 18 standard speeds from 1 rpm to ⅛ rpd, plus many special time ranges.

CRAMER CONTROLS
CORPORATION
Box 6 , Centerbrook, Connecticut

Circle 479 on Page 19

brass inserts threaded No. 8-32 to ¼-20, male studs or threads, or plain cored holes. Lengths are ⅞, 1¼, 2¼, and 4 in. Handles can be molded for specific applications requiring resistance to chemicals and heat, extra strength, electrical insulation, and low friction. **Dimco-Gray Co.**, 207 E. Sixth St., Dayton 2, Ohio. G

Circle 660 on Page 19

Snap-Action Switch

is 0.2 x 0.35 x 0.5 in. in size

No. 1SX1-T subminiature switch has many applications where small size and light weight are necessary. Weighing only 1/28 oz, it measures 0.2 x 0.35 x 0.5 in. on the case, permitting ganging ten units in a square inch of area. Contact arrangement is single-pole double-throw, and unit is rated 5 amp, 250 v ac, 30 v dc. Operating force is 6 oz maximum, and release force is 1 oz minimum. Case, cover, and plunger are high-strength plastic. Two mounting holes accept pins or

screws of 0.087 in. maximum diameter on 0.188-in. centers. **Micro Switch, Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 661 on Page 19

Plastic Screws

have high impact strength

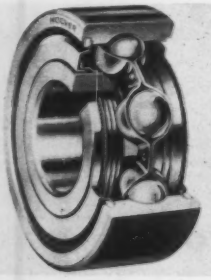
Threadlet Lexan plastic screws have shanks threaded only as far as necessary for each application to provide greater strength and stiffness in unthreaded portion of shank. Unthreaded shanks are available for use with speed nuts or clips. Screws show excellent dimensional stability at temperatures to 290 F. Other characteristics include high dielectric strength, corrosion, abrasion, and vibration resistance, and lightweight. Screws are available with any American standard thread sizes and with length of thread as specified. **Pylon Co. Inc.**, Attleboro, Mass. B

Circle 662 on Page 19

Ball Bearings

incorporate dual labyrinth seals

New cartridge ball bearings incorporate dual-labyrinth seals which hold a lifetime supply of lubricant and employ slinger action to circulate lubricant. Designed to standard double-row widths, bearings



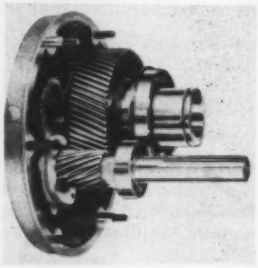
have large reservoirs to hold lubricant. Dual-labyrinth seals are formed by an inner and outer shield, fitted to create both horizontal and vertical labyrinth. Inner shield, rotating with inner raceway of bearing, provides centrifugal force that returns lubricant to working surfaces, regardless of bearing position. Bearings have high load capacities, provide quiet operation, and carry radial or thrust loads in either direction. **Hoover Ball & Bearing Co.**, 326 E. Hoover Ave., Ann Arbor, Mich. H

Circle 663 on Page 19

Speed Reducers

helical-geared units have capacities from 1/6 to 15 hp

Line of speed reducers, designed for adaptation to an unlimited variety of mounting positions, features a basic unit with either single or double-reduction helical gearing. Unit can be mounted directly on driven shaft or in standard stock horizontal or vertical bases. Four sizes of basic units provide output speeds of 10 to 431 rpm and capacities of 1/16 to 15 hp. Basic units are available in three types—reductors designed for V-belt, sprocket, or gear drive to input shaft, ratiomotors to provide direct motor drive to input shaft, and flanged reductors, which are



ratiomotor units without motor. Helical gearing in basic single-reduction unit is shown. **Boston Gear Works**, 14 Hayward St., Quincy 71, Mass. B

Circle 664 on Page 19

Flow Regulator

has rated pressure of 3000 psi

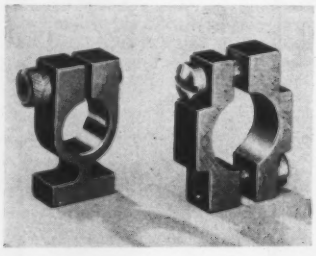
By-pass flow regulator can be used at any desired pressure up to rated pressure without affecting regulated flow or pressure. Recommended maximum inlet flow is 25 gpm; recommended maximum regulated flow is 10 gpm. Rated pressure is 3000 psi. A relief valve can be used to limit regulated-flow pressure. It is installed in either regulated flow port, and does not limit by-pass flow pressure. **Waterman Engineering Co.**, 725 Custer Ave., Evanston, Ill. J

Circle 665 on Page 19

Component Clamps

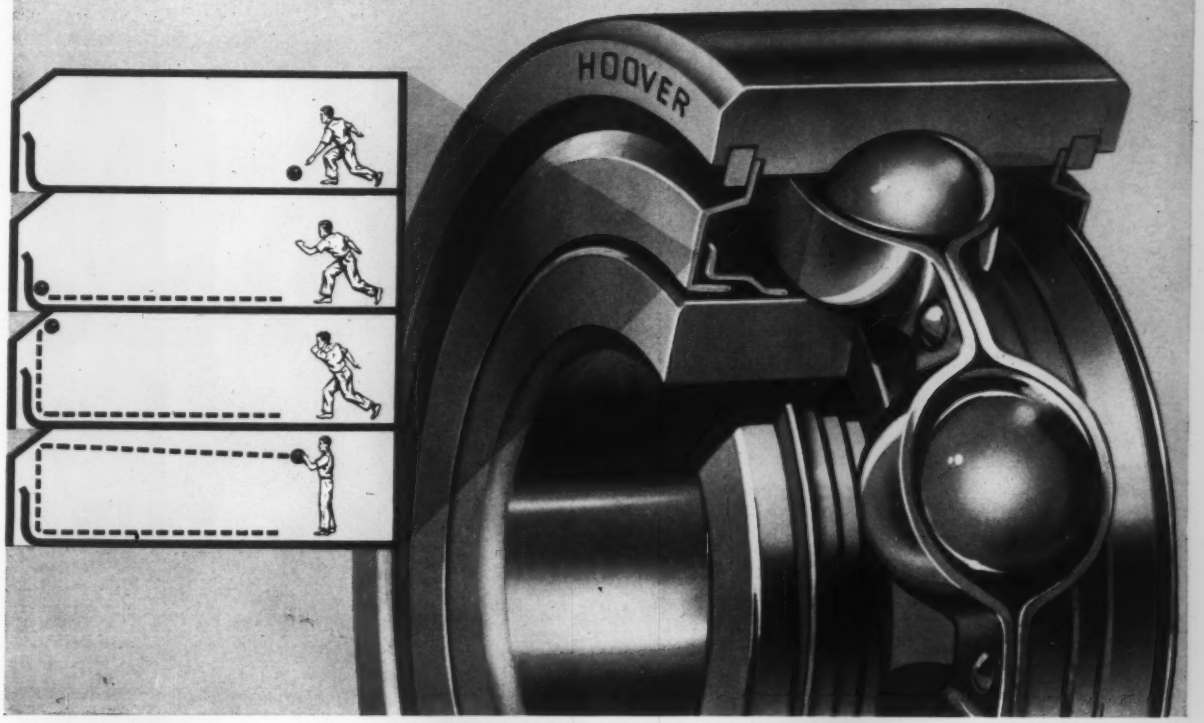
in gear and servo component mounting types

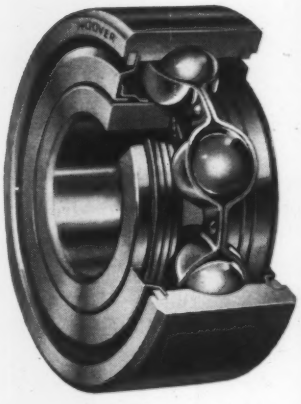
New line of clamps is available in servo component mounting and standard gear types. Gear-clamp



"Slinger Action" Circulates Locked-In Lube

in hoover cartridge bearings with dual labyrinth seals





Depend on Hoover to design a bearing that not only carries a lifetime supply of factory-selected, sealed-in lube, but also circulates the lube so effectively that maximum performance is assured for years. Hoover Dual Labyrinth Seals utilize centrifugal force to return lube again and again to the working surfaces. There is no chance for dirt to enter the bearing. Standard double row bearing width design assures extra large lube capacity. Standard bore and outside diameters simplify installation and replacement problems. Shields are easily removed for relubrication or servicing if required.

Hoover Cartridge Bearings are precision made with super smooth *Hoover Honed* Raceways and *Micro-Velvet* Balls, assuring high load capacity, smooth performance, hushed quietness.

Hoover Honed and *Micro-Velvet* are Hoover Trademarks.

hoover

BALL AND BEARING COMPANY

ANN ARBOR, MICHIGAN

LOS ANGELES SALES OFFICE AND WAREHOUSE: 2020 SOUTH FIGUEROA, LOS ANGELES 7, CALIFORNIA

Hoover Ball and Bearing Company
Ann Arbor, Michigan

Please send your new Bulletin 104, giving complete information on Hoover Cartridge Bearings.

Name_____

Title_____

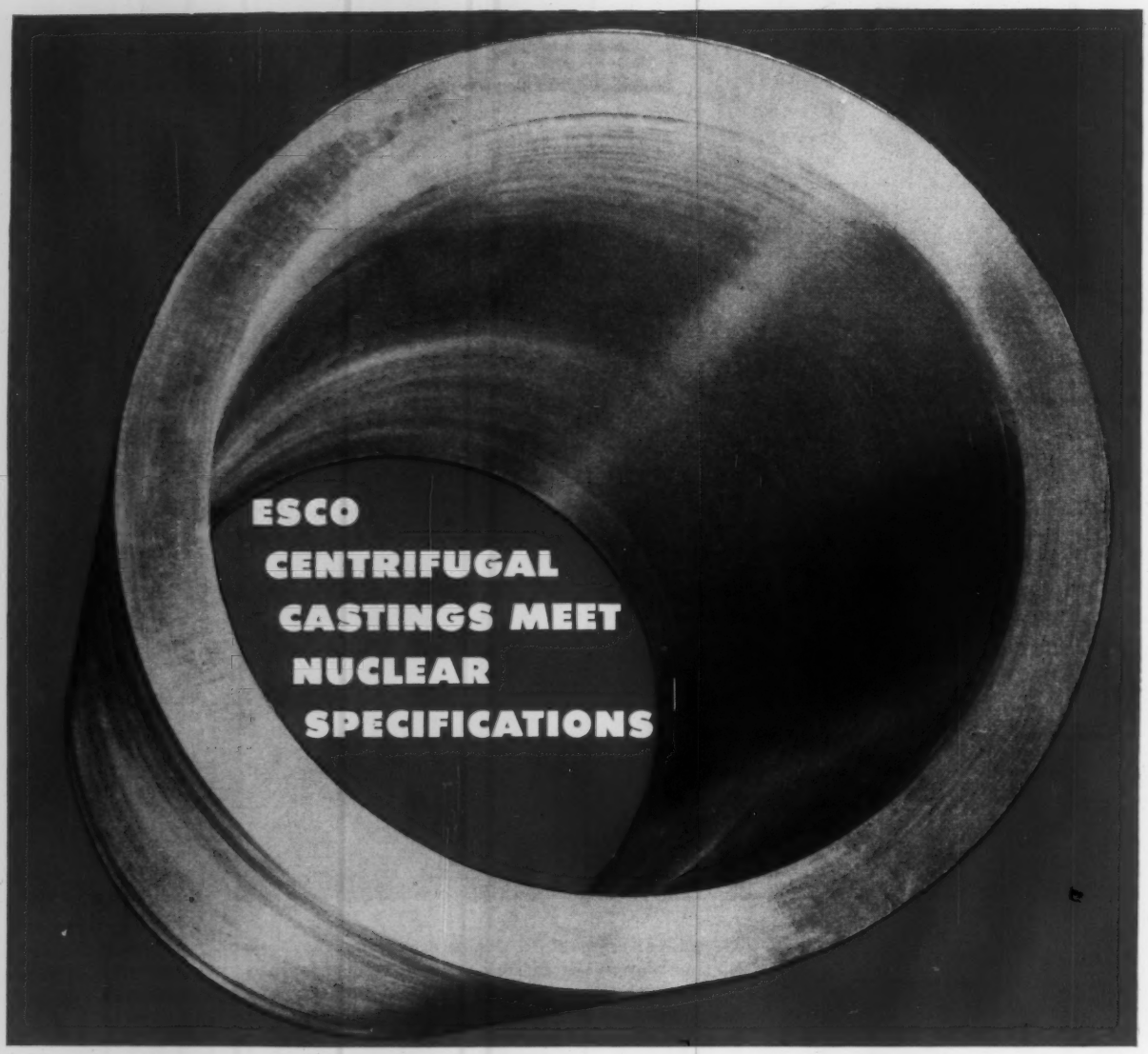
Company_____

Address_____

City_____ Zone____ State_____

MD-8

Circle 480 on Page 19



ESCO Spuncast®, a centrifugal casting process for making symmetrical, tubular parts, is especially adapted to the manufacture of nuclear stator shells, piping and scram rods, for atomic power installations.

The Stator shell (illustrated), used to make "canned" or hermetically sealed pump motor housings, is a 1,300-lb. Spuncast casting. The "built-in hole" saves countless hours of machining time as well as substantial savings in waste metal.

Cast to rigid specifications (MIL-S-18262, Class 1, 100% dye penetrant and radiograph inspected to ASTM E71 class 2, standard), these stator shells are typical of the exacting metallurgical jobs handled economically every day at *ESCO*. The Spuncast process is only one of several processes available at *ESCO*.

Call your nearest ESCO representative today for details. Ask for your free copy of "How to Cut Costs With ESCO Spuncast", a 12-page brochure, or write direct.

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MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

Offices in Most Principal Cities

ESCO INTERNATIONAL, NEW YORK, N. Y.

IN CANADA ESCO LIMITED

Circle 481 on Page 19

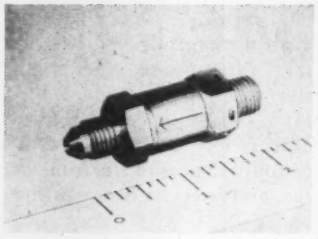
line consists of types for use at high speeds, types for speeds not to exceed 1000 rpm, and types for speeds to 200 rpm. Servo component clamp is an easy-to-use unit for positive mounting of servo components. **Sterling Precision Corp.**, 17 Matinecock Ave., Port Washington, L. I., N. Y. D

Circle 666 on Page 19

Thermal Relief Valve

miniature unit has 3.5-gpm capacity

Leakproof miniature valve relieves excess pressures caused by thermal expansion of fluids in a closed system. The valve has no internal leakage at 20 psi, and external leakage is zero at all pressures. Cracking pressure is 30 psi, ±4 psi, ca-



pacity is 3.5 gpm, and temperature range is −65 to 280 F. Weight is under 1 oz. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio. F

Circle 667 on Page 19

Laminate

of vinyl fused to steel and aluminum

Laminol consists of solid vinyl film permanently fused by extreme heat and pressure to chemically treated steel or aluminum. Color and surface embossing are very stable, and material is highly resistant to abrasion, impact, and staining. Vinyl does not affect basic fabricating properties of base metal. It can be deep drawn, bent, punched, roll formed, or crimped with standard production techniques without separation of laminate or damage to surface. Applications include use in products such as television and radio cabinets, luggage, furniture, appliances, store fixtures, and business-machine housings. Material is available with steel or aluminum base in sheets to 32 x 144 in., coils to 32 in. wide, and in popular gages and

Specify MIDLAND

WELDING NUTS

for those hard-to-reach spots

Whether you're designing or fabricating, check your fastenings. Are they in hard-to-reach places? Does assembly take two men? Those are the spots for Midland Welding Nuts.

Midland Welding Nuts take seconds to apply, yet they save hours in assembly time. And, they're a better fastener. Spot welded into place for the life of the product, Midland Welding Nuts can't come loose or cause annoying rattles.

Want cost and time-saving tips? Send for the free booklet showing you how to "Save with Midland Welding Nuts."

MIDLAND-ROSS CORPORATION

WELD NUT DIVISION

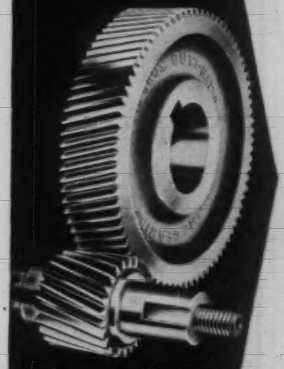
6660 MT. ELLIOTT AVENUE • DETROIT, MICHIGAN

Circle 482 on Page 19

PREMIUM GEARING
at Production-Run Prices

Foote Bros. Offers Engineered Helical and Worm Gear Sets FROM STOCK

1638 Duti-Rated COMBINATIONS



IN STOCK:

*Horsepower Ratings....1 to 200**
*Center Distances.....2" to 12"**

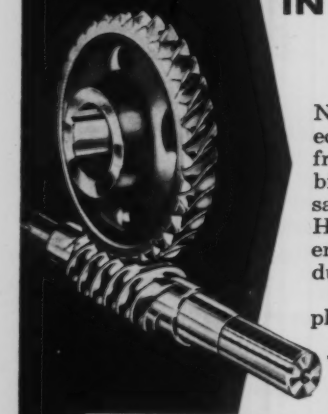
Check with Foote Bros. *before* you finalize that design. The chances are you'll find exactly what you need among the 1638 *stock* combinations of Duti-Rated Helical Gears.

When you buy Duti-Rated Gearing, you'll get more than best for your money . . . you'll get the benefit of thousands of engineering and development hours . . . and the unquestioned advantages of precision tooling and manufacturing methods. You'll get performance proven in countless Foote Bros. Line-O-Power and special drives, and Foote Bros. —Louis Allis Gearmotors. This is high hardness, accurate, balanced design gearing that will give you more load capacity and wear life per dollar.

**Larger sizes made to order from standard tooling.*

Write for DUTI-RATED catalog: Engineering Manual DR No. 2.

150 WORM GEAR COMBINATIONS



IN STOCK:

Horsepower Ratings....1 to 100†
Center Distances.....2" to 12"†

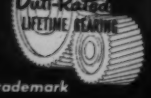
Need worm gear and worm sets? There is economy and convenience in choosing them from the many Foote Bros. worm gear combinations available from stock. This is the same gearing used in famous Foote Bros. HYGRADE Enclosed Worm Gear Drives . . . engineered, premium quality gearing at production-run prices.

Engineering Manual SW No. 1 has complete details. Write for your copy.

† Tooling available for larger worm gear sets, engineered, but not stocked, to 200 HP and 18" centers. Prompt deliveries.

ENGINEERING SERVICE

Let us help you select standard helical or worm gearing to meet your special requirements, or, let us design and build your complete unit. Place your gear problems in the hands of experienced power transmission and gear engineers. Your inquiry is invited, and there's no obligation.



this trademark stands for the finest industrial gearing made

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Boulevard, Chicago 9, Illinois

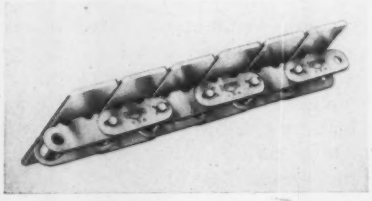
tempers. Wide range of vinyl color, texture, and thickness is also available. **American Nickeloid Co.**, Peru, Ill. I

Circle 668 on Page 19

Conveyor Chain

with top plate projection-welded to chain link plates

Dura-Weld conveyor chain has top plate welded to chain link plates by projection welding, forming a permanent metal fusion as strong as



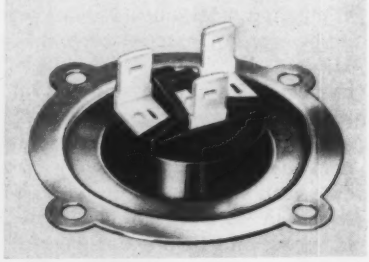
metal itself. Design gives up to 35 per cent more rail load bearing area and permits use of wider supporting rails to distribute load over greater area. Chain is detachable at any point, is interchangeable with present roller chains of the same general type, and operates over existing rails. It is available with standard carbon-steel top plates and chain, stainless-steel top plates on steel chain, or all stainless top plates and chain. **Diamond Chain Co. Inc.**, 402 Kentucky Ave., Indianapolis 7, Ind. J

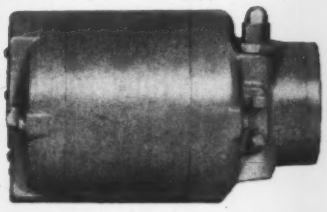
Circle 669 on Page 19

Thermostats

for motor loads to 1/3 hp

Line of Klixon 20400 automatic-reset thermostats consists of single-pole, single or double-throw, heavy-duty units. Typical uses are for fan switches in hot-air heating systems, for operating and safety controls on gas and electric clothes dryers, washer-dryers, home-heating systems, and for other appliances involving resistive loads to 24 amp and motor loads to 1/3 hp. One

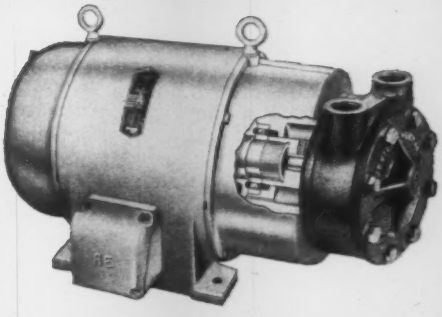




1

2

3 NEW TUTHILL close coupled pump and motor units



3

Save space, Save weight, Cut costs

Now TUTHILL offers three pump and motor combinations developed specifically for applications where space or weight are at a premium. Furnished in a wide variety of sizes and styles, one of these combinations can provide savings in hydraulic, oil burning, lubrication or other services.

The small size of these combinations solves design problems. By reducing weight they cut shipping charges. The elimination of couplings, adapters and bases means lower costs. And even more important savings are often made through the simplification of installation procedures.

Available from Stock

A wide variety of combinations are available immediately from stock, in either large or small quantities.

For example, Number 1 above is TUTHILL'S famous POWERMITE—a combination in which pump and motor are incorporated in one unit which takes up no more space than a standard electric motor (the POWERMITE shown measures only 3⅞" x 7½").

Originally restricted to large quantity applications some POWERMITE models are now available from stock for small quantity orders. The unit shown is rated for 16 GPH at 350 PSI.

For other small quantity applications TUTHILL provides a complete selection of close coupled units with the pump mounted directly on the motor. Numbers 2 and 3 above are typical.

For applications, such as hydraulics which require smaller pumps, units such as Number 2 above provide outstanding advantages. Normally they can reduce space required for pump and motor by at least 6 inches, and cut weight by several pounds. Capacities range from 20 to 300 GPH. Pumps are available for pressures up to 1500 PSI.

Larger pump and motor combinations, such as Number 3 above, can be provided with capacities up to 50 GPM, for pressures up to 400 PSI.

If you are trying to put a pump and motor into a small space, TUTHILL has the answer. Write for details.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

☐ Please forward complete information on TUTHILL close-coupled Pump and Motor Units for_____GPH at_____PSI.

☐ Please have your representative call.

NAME_____TITLE_____

COMPANY_____

STREET_____

CITY_____

STATE_____

Circle 484 on Page 19

Spur Gear Clusters

Worm Wheels

Spiral Gears

Spur Gear Clusters

Spurs with Threaded Hub

. . . *specify* Boehme Fine Pitch Precision Gears . . . manufactured from ⅛" to 5" O.D.—180—16 D.P., AGMA Precision #3.

Write today for full details on Boehme Gears and Precision Manufacturing facilities. There is no obligation of course.

H. O. Boehme, Inc.
Designers and Manufacturers Communication Equipment Precision Electro-Mechanical Apparatus Since 1917
915 Broadway New York 10, N.Y.

Circle 485 on Page 19

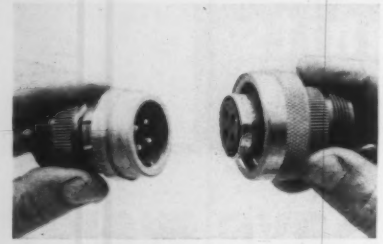
model, designated 20402, is for millivolt control circuits and thermocouple generator systems, solenoids, and relays. Normally-open and normally-closed contact types are available. Thermostats are fixed-temperature units available with settings from − 10 to 350 F. Variety of mounting and flange designs permits mounting in any position. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass. B

Circle 670 on Page 19

Quick-Disconnect Adaptor

for electrical connectors

New quick-disconnect adaptor converts a standard AN/MS screw-on electrical connector into an automatic, positive-action snap-on connector. Pin and socket contacts are



maximum engaged at each usage. Audible click indicates the parts are connected, and they will not vibrate loose. **E. B. Wiggins Oil Tool Co. Inc.**, 3424 E. Olympic Blvd., Los Angeles 23, Calif. L

Circle 671 on Page 19

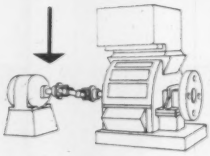
Motor-Driven Timer

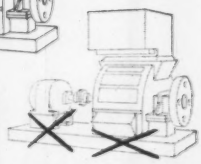
with 1, 3, and 5-min timing units

Synchronous motor-driven timer, available with 1, 3, and 5-min timing units, provides a wide range of settings. One-minute unit is adjustable in 1-sec increments from 0 to 60 sec; 3-min unit is adjustable in 3-sec increments, 0 to 180 sec; 5-min unit is adjustable in 5-sec increments from 0 to 300 sec. Terminal board and mounting base combination provides easy interchange of timing units. Quick-make and quick-break contacts in timer housing mate with terminal strips on mounting base to eliminate interwiring. Synchronous motor operates on 110 v 60 cycles. Control transformer and terminal block can be added to provide 220, 440,

WATSON COUPLINGS Engineering Notes

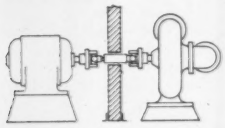
How to Eliminate the Cost and Problems of Critical Alignment



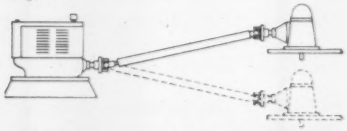


A WATSON coupling shaft working at any angle from 1 to 8 degrees transmits power as efficiently as a flexible coupling, yet offers substantial savings in design engineering time and installation cost. Angles up to 20 degrees can be handled (depending on RPM). No painstaking axial alignment is required; simple, low-cost concrete foundations poured on the site replace costly unit base plates.

In addition to substantial savings in engineering design and installation time and cost, the use of WATSON coupling shafts offers:



WIDEST LATITUDE IN LOCATION of driving and driven elements for best utilization of space, distribution of weight, isolation of motor or engine, provision for maintenance or working space.



PROVISION FOR RELATIVE MOVEMENT between driving and driven elements, either intentional or as a result of structural deflection or foundation shifts.

WATSON Coupling Shafts are promptly available in 9 sizes, 10 to 800 h.p., for speeds to 4,000 r.p.m. and more. Why not get the facts — now. 8-page Engineering Data Bulletin F-11 is yours for the asking; please address Dept. J-8.

WATSON **H. S. WATSON COMPANY**
1316 - 67TH ST., EMERYVILLE 8, CALIF.
1606 LASKEY ROAD, TOLEDO 12, OHIO 4

Circle 486 on Page 19

With this **new** socket head cap screw you can Pre-Load without indentation!

the new P-K® PRE-LODE

Now . . . Parker-Kalon's new PRE-LODE Socket Head Cap Screw gives you *greater bearing surface under the head than ever before!* With this new head, a research achievement resulting from the combined efforts of the Socket Screw Manufacturers' Technical Committee, you can now apply higher torque . . . pre-load the fastener for maximum holding power without danger of marring or indenting softer materials in which the screw engages. This means greater load carrying capacity and better functioning in holes having a greater body clearance. P-K's PRE-LODE Socket Head Cap Screws are designed for high tightening. In many cases, the socket has been enlarged to allow more wrenching area. Standard sizes ¼" to 1" PRE-LODE Socket Head Cap Screws are *Size-Marked* for easy identification, and are manufactured to exacting specifications. Available now from your authorized P-K distributor at no increase in cost. Write today for complete technical data and samples.

Sold Everywhere Through Leading Industrial Supply Distributors.

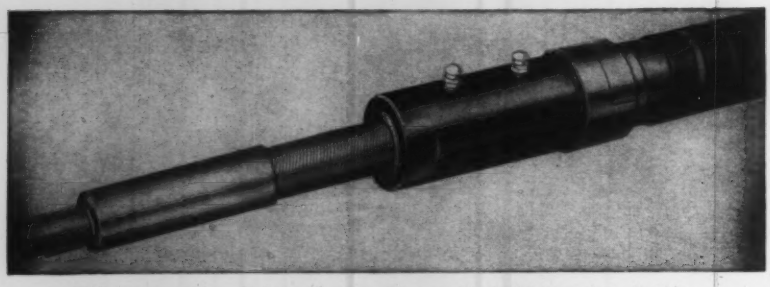
PARKER-KALON® *PRE-LODE Socket Head Cap Screws*

PARKER-KALON DIVISION, General American Transportation Corporation, Clifton, New Jersey.

Only Parker-Kalon offers both PRE-LODE and SIZE-MARK in Socket Head Cap Screws

STOW FLEXIBLE SHAFTING
The Ideal PTO Drive

1¼" flexible shaft under tractor-trailer transmitting 10 HP.



1¼" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from ¼ inch to 1¼ inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems *in advance.* The know-how of 82 years' experience goes into every STOW flexible shaft!

STOW flexible shafts are being used on trucks and tractor-trailers to:

- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.
- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

STOW MANUFACTURING CO.

11 Shear St. Binghamton, New York

Circle 488 on Page 19

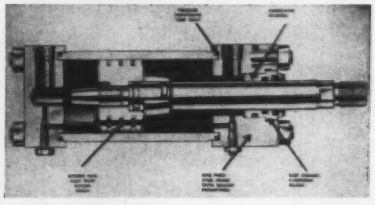
or 550-v 60-cycle service. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee 1, Wis. K

Circle 672 on Page 19

Hydraulic Cylinder

has pressure-tightening tube seal

Powrdraulic hydraulic cylinder incorporates an O-ring seal located on the OD of the tube and fully confined between tube and cylinder head. Minute expansion of tube under pressure squeezes O-ring, increasing tightness of the seal, which remains tight at all pressures. Cylinder is rated at 2000 to 3000 psi nonshock, and bore sizes range from 1½ to 8 in. Availability of 13 basic models and choice of rod sizes permit selection of a standard cylinder for almost all applications. Cylinders



have industry standard mounting dimensions and conform to JIC recommendations. **Hanna Engineering Works**, 1765 Elston Ave., Chicago 22, Ill. I

Circle 673 on Page 19

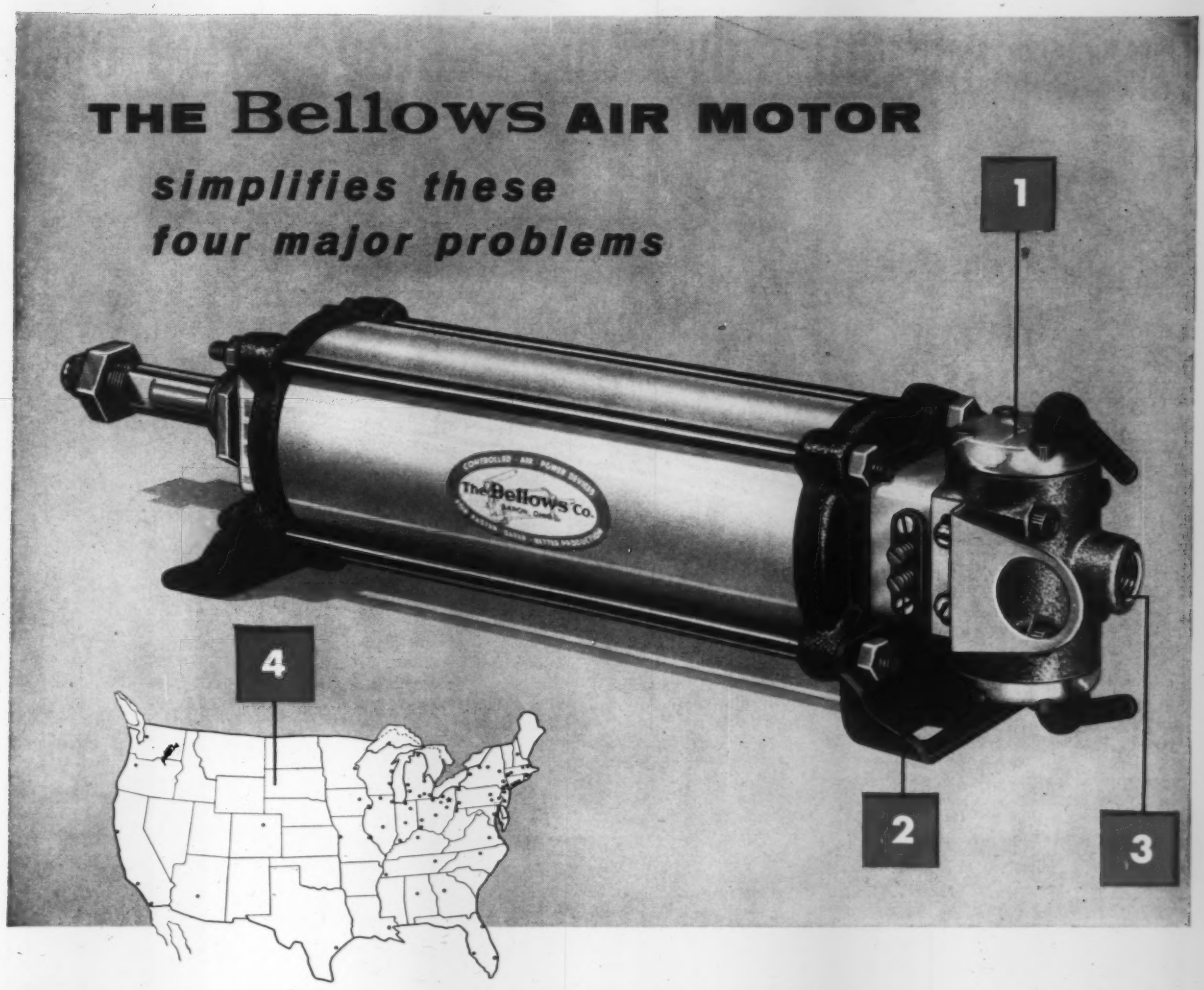
Clip Fastener

secures transistors to electronic equipment chassis

Spring-steel Speed Clip, designed to secure transistors to electronic equipment chassis, is snapped into panel holes where it retains itself under live spring tension. Tubular retaining collar has excellent heat-sink properties since it completely encircles transistor, drawing heat from all directions and transmitting it

THE Bellows AIR MOTOR

simplifies these four major problems



1 **Built-in electrically controlled directional valve, either 8 or 110 v., simplifies design problems.**

2 **Built-in speed controls for accurate regulation of piston rod speed simplify control problems.**

3 **The single air connection, which can be made with flexible air hose, simplifies installation problems.**

4 **More than 125 Bellows Field Engineers in the United States and Canada simplify service problems.**

Design, control, installation and service are problems every O.E.M. Design Engineer faces when selecting components for automation.

In pneumatic design, the Bellows Air Motor—the air cylinder with the built-in valve—simplifies his problems. Instead of separate valving for directional control, separate valving for speed control, multiple mounting, complex and cumbersome piping for air supply—he works with one compact, complete power unit.

Not only are design and control simplified when you specify "Bellows", but installation costs are less; and you know wherever your machine is shipped, a Bellows Field Engineer will be available for service if it is ever needed.

Write for Bulletin BM-25
"The Story of The Bellows Air Motor"
Address: Dept. MD-858
The Bellows Co., Akron 9, Ohio

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

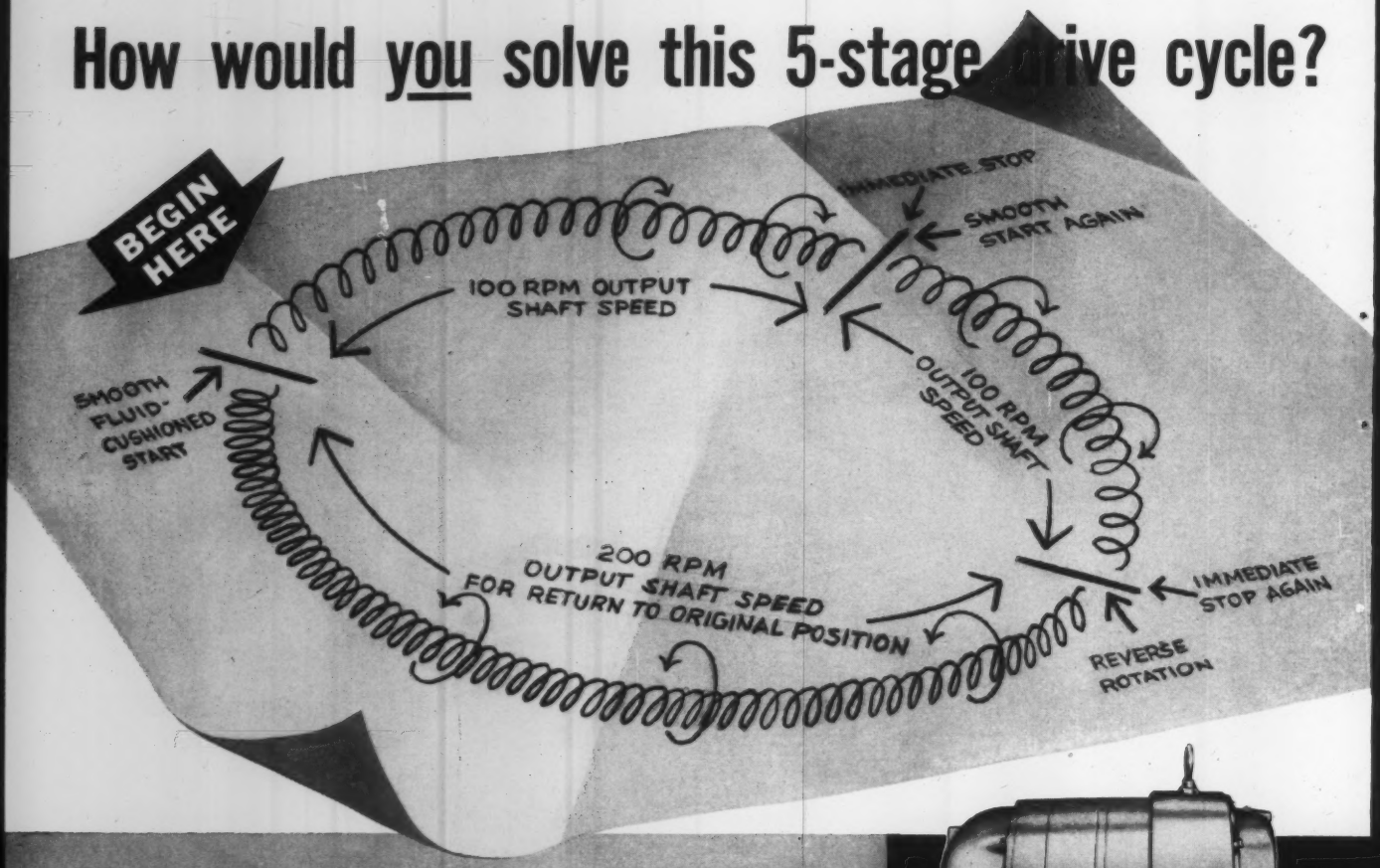
AKRON 9, OHIO

In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ont.

644B

Circle 489 on Page 19

How would you solve this 5-stage drive cycle?



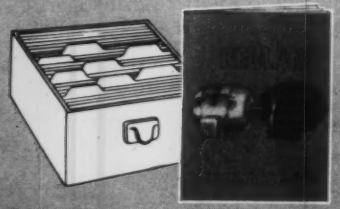
This one *modern* Reuland power package *does* all five!

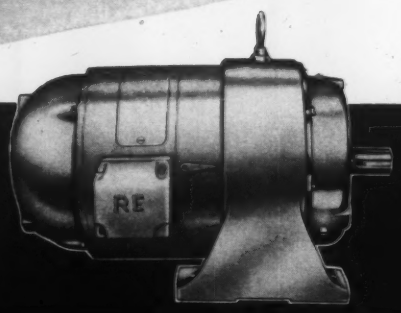
Today's ingenous, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive *package*.

Reuland's "Xpandable Design" idea *originated* this modern new approach several years ago. With this unique system, drives incorporating many varied factors are supplied as a single unit . . . *tailored to the needs of each individual customer.*

Modern Reuland Power demonstrates every day that there *is* something new in electric motors. Whether *your* own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request
Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.





MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

RE®

REULAND ELECTRIC COMPANY

WESTERN DIVISION: Alhambra, California
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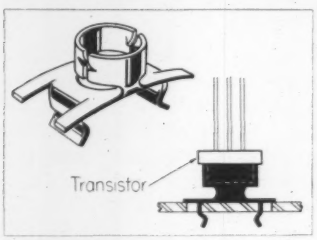
through spring legs and tabs into panel. Openings at both sides and at bottom of fastener allow air to circulate and increase heat dissipation. Four small barbs and compression of fastener collar retain transistor in



a firm, vibrationproof grip. Unit accommodates all transistors employing standard TO-9 outline. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland, Ohio. F

Circle 674 on Page 19

Miniature Servo Motor

accelerates to 1450 rpm in only 0.004 sec

Model M-100 60-cycle servo motor is available for automation of machine tools, heating devices and systems, and processing and packaging machinery used in the production of consumer products. Unit reaches full speed of 1450 rpm in 0.004 sec. It has excellent internal damping qualities, high torque, rapid stall ac-

celeration, and high resistance to shock and extreme temperatures. Motor is available in Frame 11 size. **Dynamic Instrument Corp.**, 59 New York Ave., Westbury, L. I., N. Y. D

Circle 675 on Page 19

Spherical Bearings

are made by powder metallurgy

New sintered-metal spherical bearings have a high load capacity for their size, and operate at relatively high speeds. Balls are high-density, through-hardened, powdered

MORE THAN 8000 STANDARD SPECIFICATIONS have been established by Judson L. Thomson Mfg. Co. for the five basic types of rivets: semi-tubular, deep-drilled, bifurcated (split), outside prong, and shouldered.

Seventeen Key Questions Simplify Value Analysis of Fasteners

By KENNETH E. JOY, General Sales Mgr.
Judson L. Thomson Manufacturing Co.

In approaching the problem of selecting fasteners that provide the greatest utility per unit of cost, it pays to be completely objective. Playing favorites or rejecting the old for the new can often prove costly. An unbiased approach to the analysis of fasteners, however, can slow down a project unless you have a system for quickly evaluating the many possible alternatives.

Such a system must have a starting point. May I suggest rivets as the logical start? There are two reasons why. As cold-formed fasteners, mass-produced at rates ranging from 75 to 400 a minute, rivets cost less than most other fasteners. Machine-set at rates as high as 180 a minute, they keep assembly costs at a minimum.

You can simplify the evaluation of rivets by answering the following seventeen questions:

1. Have you considered rivets for all assemblies that call for permanent fastening?
2. Where welding is now being used, can rivets plus gaskets or sealants provide comparable air tightness or water tightness at lower cost?
3. Where stapling is being used, can the heads of rivets add decoration or utility at little or no extra cost?
4. Where stitching is being used, can rivets replace or supplement it for greater strength?
5. Can rivets replace expensive removable fasteners where assembly is not absolutely essential?
6. Can self-piercing rivets — deep-drilled or bifurcated (split) — eliminate the cost of drilling or punching holes in the material to be assembled?
7. Can the addition of caps or burrs (washers) under the clinch of rivets permit their use on brittle or easily torn materials now fastened or joined a more expensive way?
8. Can the use of pneumatic or hydraulic rivet-setting machines which control impact allow the use of rivets for assembling fragile materials?
9. Can a change in assembly design provide access for machine-set rivets to replace more costly fasteners?
10. Can a change in assembly sequence introduce the speed and economy of riveting?
11. Can special cold-formed rivets replace more costly parts as pivots, contacts, stud followers and the like?

If the above questions lead to the decision that you can switch from other fasteners to rivets, the following questions will help you evaluate sources of rivets.

12. Does the rivet manufacturer make all kinds of rivets to give you complete freedom of choice?
13. How many standard specifications does the rivet manufacturer offer to lessen the possibility of more costly specials?
14. When special rivets are necessary does the manufacturer have experienced engineers who can solve new problems fast?
15. Does the rivet manufacturer also make machines to assure trouble-free assembly at lowest cost?
16. Does the supplier concentrate his engineering, production and quality control talent in one plant for expediting delivery of top quality rivets?
17. Does the supplier stock adequate supplies of most-wanted standard rivets in conveniently located points?

Free "Fastener Fact File"

This new manual of rivet and rivet setting machines provides complete information needed for efficient value analysis of fasteners. Write Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Massachusetts.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

←Circle 490 on Page 19

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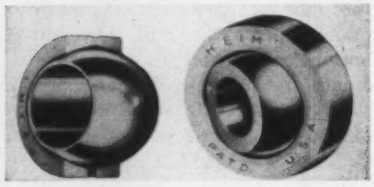


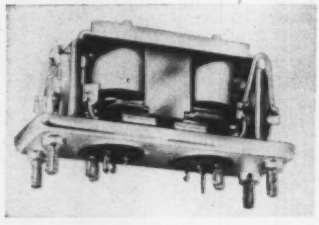
iron alloy, and outer members are sintered iron or sintered bronze with controlled porosity. Bearing holds up to 20 per cent of its own volume in oil, providing longer bearing life with less frequent relubrication necessary. Bearing presents a large surface-supporting area, and rotates to accommodate shaft misalignment in all directions. **Heim Co.**, 20 Sanford St., Fairfield, Conn. B

Circle 676 on Page 19

Latching Relay

for 30-amp contactor applications

Loads up to 30 amp at 30 v dc are switched by KG11DG dual-coil magnetic latching relay. Unit is for 30-amp contactor applications where resistance to 100-g shock and 30-g vibration to 2000 cps is required. It operates on 2.6 w, 12 millisec pulses; contacts transfer in 2 millisec. Relay operates in ambient temperatures from − 65 to



125 C. It is 3.70 in. wide x 1-11/32 in. deep x 1-13/16 in. high, and mounts by four No. 8-32 studs on 3¼ x ¾-in. centers. **Technical Information Dept., Potter & Brumfield Inc.**, Princeton, Ind. J

Circle 677 on Page 19

Aluminum Casting Alloy

has high tensile and yield strength

High-purity aluminum-silicon-magnesium casting alloy, designated X357, combines high tensile and yield strengths with good ductility after heat treatment. It has good castability, machinability, dimensional stability, and resistance to

Prongs snap into
punched or drilled hole

CUSTOM-DESIGNED AND MASS PRODUCED TO YOUR PARTICULAR REQUIREMENTS

Dot plug buttons were originally used in automobiles to fill spaces on standard models which, on de luxe models would be occupied by such extras as cigarette lighters, radio controls and so on. They are now also widely used as lenses for indicator lights and as identification buttons on instrument and control panels of all kinds.

Available in clear or colored plastics... brass or steel in all standard finishes... embossed and enamel-filled or molded to show company insignia or other identification symbols . . . Dot plug buttons snap into place and stay where they're put even under conditions of extreme vibration. Yet they can be removed and replaced repeatedly without damage.

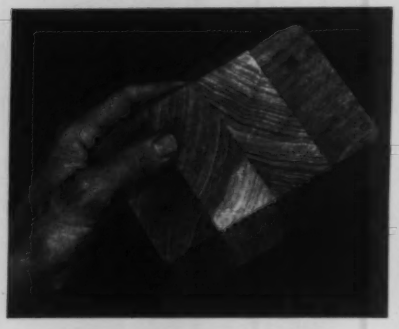
CARR FASTENER COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION 31 Ames Street, Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

Circle 492 on Page 19

WHAT'S YOUR WOOD PROBLEM?

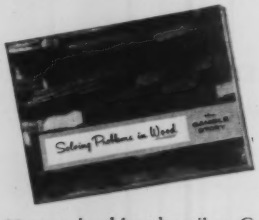


Gamble research lengthens industrial floor life up to 10 times

THE PROBLEM. Ordinary industrial wood block flooring was proving a costly maintenance headache in plants where certain floor areas — loading docks, aisleways, intersections — were subject to heavy traffic loads. Flooring in these areas was rapidly breaking up.

THE RESULT of Gamble testing and development: a laminated end-grain hickory flooring specially made for these heavy-load "hot spots". Gamble engineered flooring lasts up to 10 times longer when subjected to day-in, day-out punishing loads that would quickly break up an ordinary floor. Chances are, Gamble could help with *your* wood problem.

Send for FREE booklet Illustrating GAMBLE services



This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Bros., Inc., 4619 Allmond Ave., Louisville 9, Ky.

GAMBLE BROTHERS
Incorporated
Louisville 9, Kentucky
If the problem involves WOOD —GAMBLE can help!

Circle 493 on Page 19

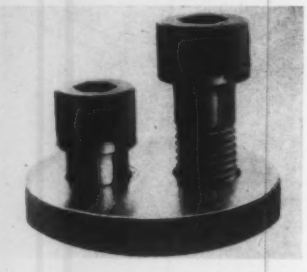
corrosion. Alloy has applications in highly stressed aircraft and missile structures, high-velocity blowers and impellers, and other uses where high yield strength is important. Permanent-mold properties are 52,000 psi tensile strength, 43,000 psi yield strength, and 5 per cent elongation. **Kaiser Aluminum & Chemical Sales Inc.**, Dept. NR-16, 919 N. Michigan Ave., Chicago 11, Ill. I

Circle 678 on Page 19

Cap Screw

has large diameter head

Unbrako pHd socket-head cap screw (right) has larger head diameter, permitting it to be loaded as much as 134 per cent more before it indents the material being fastened. Larger head reduces bearing pressure by spreading load over a greater area, holding bearing stress to 80



per cent of axial tensile load on the screw. Screws are available with larger heads in 5/16, 7/16, 9/16, 5/8, 3/4, 7/8, and 1-in. body diameters. **Standard Pressed Steel Co.**, Jenkintown, Pa. C

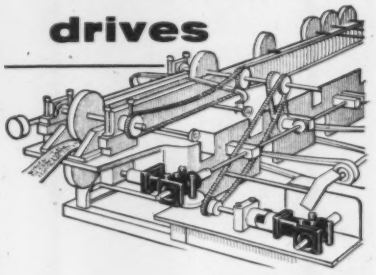
Circle 679 on Page 19

Drum Switch

for use with ac and dc motors

No. 350 drum switch is for starting, stopping, and reversing small ac and dc motors. It is furnished in surface-mounted NEMA Type-1 enclosures, or with oiltight cover plate for cavity mounting in a machine base. New cover completely exposes switch mechanism for easy wiring, and terminal screws are accessible from front instead of from side. Switch mechanism is mounted separately from enclosure, so that external forces which distort enclosure cannot cause binding in the switch. Switch is available for 1½-

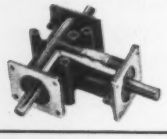
ANGLgear® obsoletes open gear drives



Prototype of this belt-finishing machine utilized exposed miter gears for 90° drive (foreground). Change to ANGLgears solved problems of noise, lubrication failure, disengagement and operator safety.

Compact, high capacity ANGLgear—the standardized 90° power unit—offers you a number of advantages over open gear drives. Featuring 4 or 5-way mounting, it is easier to design into your power transmission systems, easier to install. Incorporating ball bearing-mounted bevel gears, it eliminates slippage and minimizes backlash problems, cannot possibly become disengaged. Completely enclosed, it presents no safety hazard. Permanently lubricated, it requires little or no maintenance. And not the least important, ANGLgear invariably costs less than other types of drives, while at the same time giving your product a neater appearance.

You can specify ANGLgear from stock in ⅓, 1, 2¼ and 5 hp ratings, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting. See our literature in Sweet's Product Design File or contact our local distributor.



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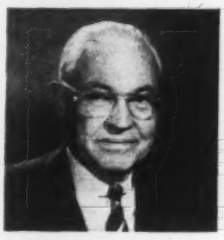
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 494 on Page 19

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Select proper bolt diameter

An erroneous rule of thumb worth forgetting is that no bolt under ⅝" should be used where fastened members are under stress. Yet bolts ½-inch and smaller take plenty of external loading.

HOW TO LOOK AT IT

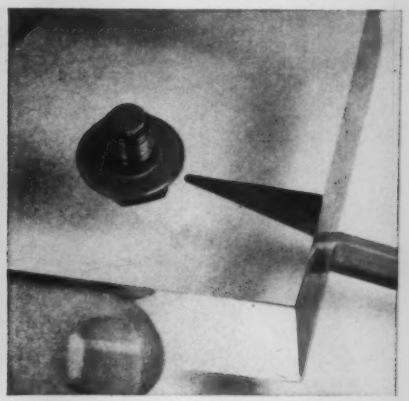
Primarily, you have to satisfy the stress requirements . . . the load. So select bolts on that same basis: the actual strength to sustain that load.

Calculating the strength requirements will tell you what bolt tensile, size, and number you need. If smaller bolts suffice, use them to avoid the penalty of overdesign. Holes can be smaller which means faster drilling and tapping. You have a chance to save materials since with smaller bolt holes, fastened members can often be made smaller too. You may also be able to standardize on a single size, saving assembly-line time.

SIZE VS. SAFETY

Remember that for a given grade of material, size tells you *capacity* of a bolt, not its *safety*. If you *tighten* a bolt to capacity, then you get safety. That's why a smaller bolt properly tightened is better and safer than a larger bolt sloppily tightened, especially where the loads are dynamic. Obviously, you reduce risk of under-torqued bolts as you reduce their size.

The new RB&W "SPIN SEAL" fasteners have spring-type washer with adhering flow-in seal . . . pre-assembled to standard machine or tapping screw.



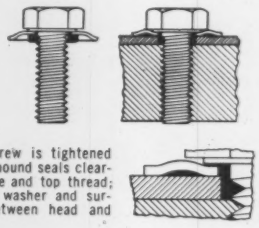
Flow-in sealant is confined by washer. Note how seal fills space under head and flows around and into threads in tightened SPIN-SEAL screw.

New SPIN-SEAL* screws give leakproof fastening

Here is a new type of composite fastener that seals by means of a unique flow-in sealant and washer.†

ASSURES TRIPLE SEAL

Concave in shape, the heat treated springy washer confines and controls the flow of sealing compound. Tightening the screw forces sealant into various spaces around (1) threads, (2) head and (3) clearance hole to give hermetic sealing.



When screw is tightened the compound seals clearance hole and top thread; between washer and surface; between head and washer.

The washer has ability to conform to curved surfaces and still seal securely against hydrostatic pressures and wind driven water. Its spring tension and flat rim give the added advantage of dynamic metal to metal seal.

ONLY THE SCREW TURNS

Washer does not turn with the screw. This prevents twisting or tearing the sealing "gasket", marring of polished surfaces, or gouging of painted finishes.

The flow-in gasketing compound is plastic rather than elastic. Stable and non aging, it won't split or ozone-check under pressure. It gives controlled flow into clearance spaces. Compounds are available to seal out water or oil.

Send for Bulletin SS-1 which gives details on RB&W "SPIN-SEAL" fasteners. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y. *T.M.

†U. S. & Can. Pats. Pend.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

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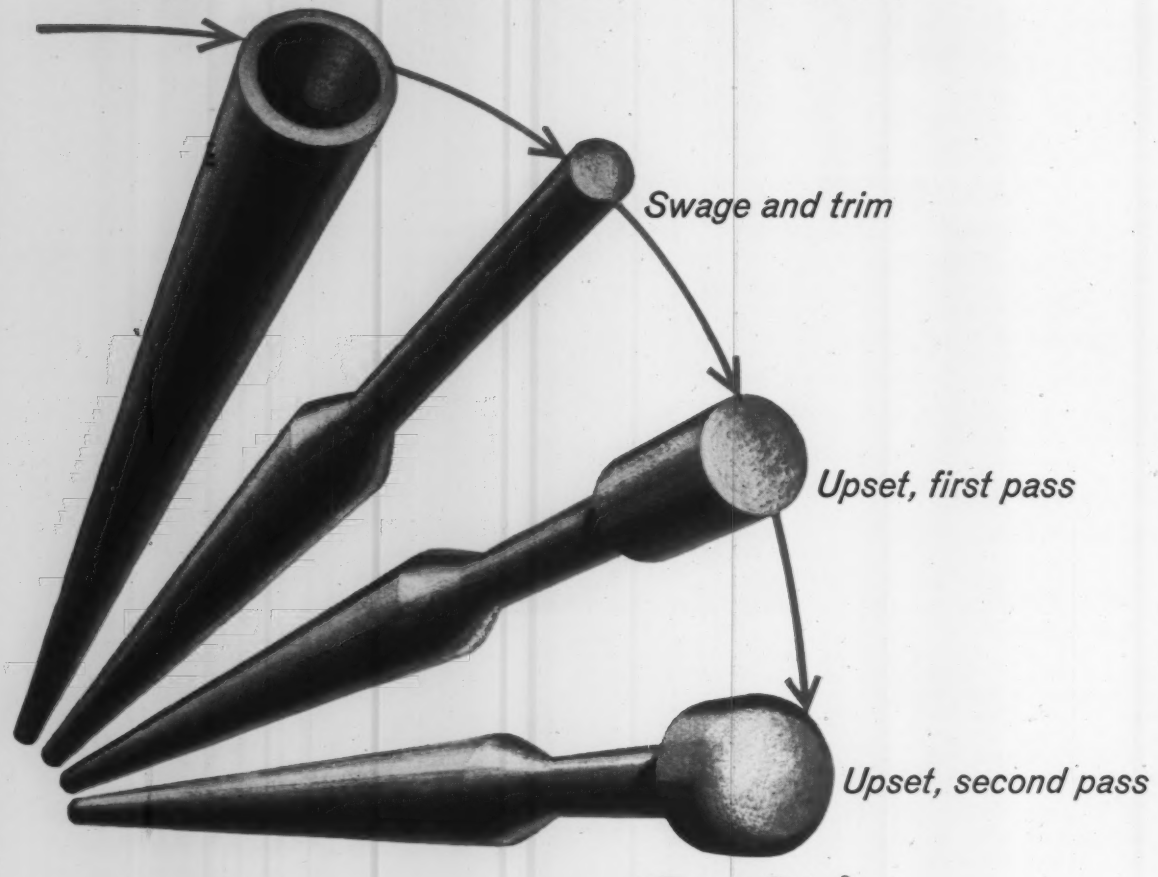
Start with OSTUCO TUBING



and end up with a 34% *saving*

Here's a cost-cutting case history right in the Ohio Seamless mill. It proves we take our own medicine—*and like it.* You may, too.

Formerly, mandrels for rolling Ostuco Tubing on our Assel mill were made from two pieces. A shaped end, hogged out of solid bar stock, was welded to a long tube. Expensive to machine, weld and process.

We decided to *forge the mandrels entirely from Ostuco Seamless Steel Tubing.* In three steps—swage, upset and finish-form—we now produce better mandrels . . . ready for use without any machining whatsoever, *and save 34% over former processing methods.*

Chances are good that Ostuco Tubing is the right prescription for slashing your production costs, too. For expert advice, contact our nearest sales office or our plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

AA-7225

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CANADA: Railway & Power Engr. Corp., Ltd.

EXPORT: Copperweld Steel International Company
225 Broadway
New York 7, New York

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1908 1958

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Circle 496 on Page 19

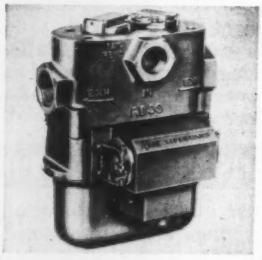
hp 110-v and 2-hp 220-v single-phase motors, 2-hp 110-220-550-v polyphase motors, and ¼-hp 115-230 v dc motors. **Allen-Bradley Co.**, 136 W. Greenfield Ave., Milwaukee 4, Wis. K

Circle 680 on Page 19

Three-Way Valve

incorporates lock-out unit

C-type Lifeguard valve, designed for use with pneumatic clutch or clutch-brake controlled power presses, senses potential malfunction within itself and locks out to prevent unsafe press operation. It is a three-way unit which can be recocked pneumatically or manually, permitting flexibility in location. Two three-way valve units are connected pneumatically in parallel, each with its own pilot-valve operator and solenoid actuator. Attached lock-out unit supplies inlet air to pilot-valve



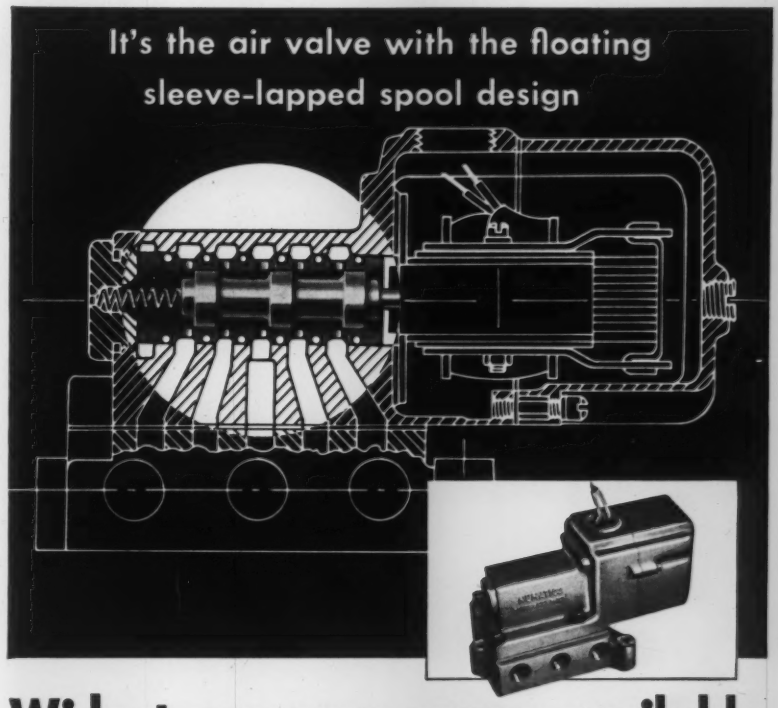
operator. Repeated lock-out indicates that some maintenance is necessary before press can be operated with complete safety. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit 3, Mich. H

Circle 681 on Page 19

Polarized Relays

handle 1000 pulses per sec

Diamond H Series P high-speed polarized relays are designed for use in a variety of electronic applications and in communications equip-



Widest pressure range available

It's a fact! Numatics air valves operate from 28″ Hg vacuum to 300 P.S.I. And this is *standard* with Numatics valves. One valve covers this entire pressure range . . . no external pilot lines, no special springs, no boosters, no extra "gimmicks" of any kind are required. Now, add this important advantage to all the other plus benefits of Numatics valves: *lightning response* . . . 11 milliseconds from energizing to wide open; *consistent action* . . . completely unaffected by pressure fluctuations; *wider speed range* . . . from high cycle welding guns to intermittent and slow-speed automation; *more sizes, solenoids, actions and mountings* than you'll find in any other valve line currently on the market. And what does it all add up to? . . . an air valve that just can't be matched for application, versatility or operational flexibility! Want more details? Write for your catalog today . . . or, better, call your nearby Numatics representative.

You asked for it . . . NUMATICS has come up with it!

LCV CUSHION VALVE

Here it is . . . Numatics amazing LCV. Stops air cylinders without impact . . . allows faster machine cycles . . . reduces material breakage . . . saves wear and tear on machines. Even with heavy loads, the LCV provides controlled deceleration by regulating piston speed with extreme accuracy.

NUMATICS, Inc. HIGHLAND, MICHIGAN

SALES REPRESENTATIVES FROM COAST TO COAST

Circle 497 on Page 19

STRONGEST MAN IN WHEELS

Call on the most complete design-to-delivery-date service in the wheel industry today.

Your ELECTRIC sales engineer holds up his end and then some! Call on him to put his shoulder to your problem with quick answers and cost-cutting suggestions for new designs or redesigns.

Call, too, on the famous follow-through that only ELECTRIC's automated operation, handy location and wide agricultural and industrial experience offer you.

For the precise disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you want, call or write today.

"What we sell is service"

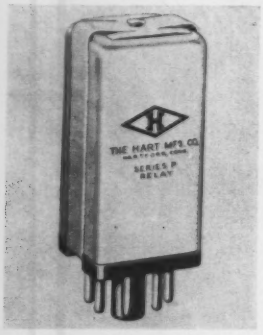
ELECTRIC WHEEL CO.

Write to Department 6B,
1120 N. 28th St., Quincy, Illinois, BAldwin 2-5320

DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

Circle 498 on Page 19

ment. They provide consistent performance with low distortion, and under some conditions handle over 1000 pulses per sec. Single pole, double throw, with two independent coils, they are available with various



coil resistances to 5000 ohms each coil. Contact ratings vary with switching speed, ranging from 60 ma to 2 amp with voltages to 120 ac or dc. Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn. B

Circle 682 on Page 19

Fasteners

for high-temperature service

Alloy-steel Huckbolt fasteners have diffused cadmium-nickel alloy plate for high-temperature service. Development permits use of standard fastener materials in temperature applications to 900 F. Fasteners with the new plate display at 900 F cor-

rosion resistance equivalent to 400 F performance of parts having conventional cadmium plate. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 683 on Page 19

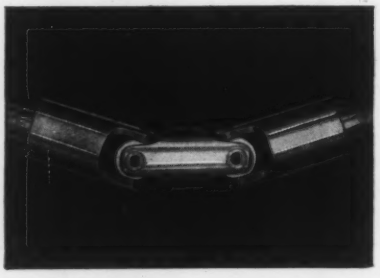
Electric Motors

are self-lubricating units of 56-frame construction

New electric motors incorporate reservoirs and feed devices which admit oil to sleeve bearings in controlled quantity after original bear-

How Curtis helped a design engineer "BEAT THE HEAT"

This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
⅜" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 499 on Page 19

THIS IS GLASS

a bulletin of practical new ideas from Corning

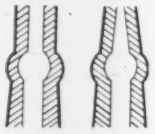
Hot tip!

This is a *glass* welding torch nozzle. You'll find them used on the inert gas welding rigs made by a number of up-to-date manufacturers.

Main reason for the *switch* to glass? You can keep close *watch* over the weld, *avoid* the kind of mistakes that can run into big money when you're working on expensive alloys.

Some of these welding nozzle tips are made out of VYCOR brand glass No. 7913, a 96% silica glass that's been *degassed*. Special firing to remove moisture reduces the tendency to deform at high operating temperatures.

All glass welding tips are fashioned from heavy-wall tubing that could be held as close as ±.001". Also, some pretty fancy machining and forming goes into them. One type calls for precision grinding of an outside taper, another for the same treatment on the inside—both for friction locking. And the tip we make for one firm has a bulb-like configuration to increase gas turbulence. All tips are fire-polished for added strength.



From all we've been able to discover, the men in the shop are quite enthusiastic about these rugged, heat-resistant glass tips that let them watch the welds go by. Likewise for the people who buy these tips from Corning and sell complete rigs to welders. They get what they need, when they need it, at a price that makes sense.

Special glasses, along with special techniques for either custom or mass production, await your appraisal. Which brings us to a standing offer: Bring us your knotty problem—product or process—and we'll see if we can't come up with a *glass* answer.

Or put some data at your fingertips by sending for Bulletin B-91, "VYCOR brand industrial glassware by Corning." In it you'll find all facts about infrared and ultraviolet transmission, heat and chemical resistance, and forms in which you can get these glasses.

How not to foul up the works

It's really very simple: If you're using spun insulation in electric motors, you have to keep the stuff from falling into the moving parts and fouling up the works.

Two things to keep in mind when selecting a material for this application: (1) It has to stand up to quite a bit of heat. (2) It *can't* be a conductor.

Some materials that are good insulators can't take the heat. Others function well at high temperatures but are not insulators.

Glass solves both problems. So, people who make electric motors build them with wedges made from PYREX brand glass No. 7740. (We supply the glass in rod form.)

This particular PYREX brand glass offers a number of useful characteristics. It is corrosion resistant and has a linear coefficient of expansion of 32.5 x 10^{-7} in/in between 0° and 300°C. Dielectric properties at 1 Mc and 20°C. are as follows:

Power factor	.46
Dielectric constant	4.6
Loss Factor	2.1

Wedges made from glass rod support spun insulation in electric motors. Glass is non-conducting and able to stand high temperature without deforming.

You can get PYREX brand glass No. 7740 in a variety of forms—pressed ware, blown ware, plate, tubing, rod and panels.

Mechanical, thermal, electrical, and chemical properties of this glass and 27 others are spelled out in Bulletin B-83. Check the coupon for a copy. Also ask for IZ-1, "Designing With Glass for Industrial, Commercial and Consumer Applications."

Blues in the white

Grand Coulee Dam is quite an impressive sight. It stands 550 feet high, and 4,173 feet wide. At night it's illuminated by 686 high wattage floodlights, covered with *colored front lenses*.

These lenses are red, green, blue, and yellow. And part of the lighting plan requires making *white* by *adding* red, green and blue.

That's where the trouble started. The equipment manufacturer required a very *precise* shade of blue. And despite years of experience in making colored glass, Corning had no blue on hand to do this job.

So our researchers came to the rescue. They developed a *special* glass and called it (for obvious reasons) "Front Glass Blue." Lenses made of this glass produced just the right shade. And along with the red, green and yellow lenses, they were *heat-resistant*, too.

Each lens used in this colorful spectacle measures 18 inches in diameter and weighs almost 7 pounds. All 686 were pressed from *standard* molds, delivered in record time.

O.K., you're not interested in color. Still there might be some glass or glass product that can be of help to you. Good introduction to the fascinating world of glass technology is the booklet, "This Is Glass." In its 64 pages you'll find facts and pictures that might give you some ideas. Remember: Corning can do almost anything with glass.

Corning means research in Glass

CORNING GLASS WORKS, 52-8 Crystal Street, Corning, New York

Please send me: B-91, "VYCOR brand industrial glassware by Corning" ☐ B-83, "Properties of Selected Commercial Glasses" ☐ IZ-1, "Designing With Glass for Industrial, Commercial and Consumer Applications" ☐ "This Is Glass" ☐.

Name.....Title.....

Company.....

Street.....

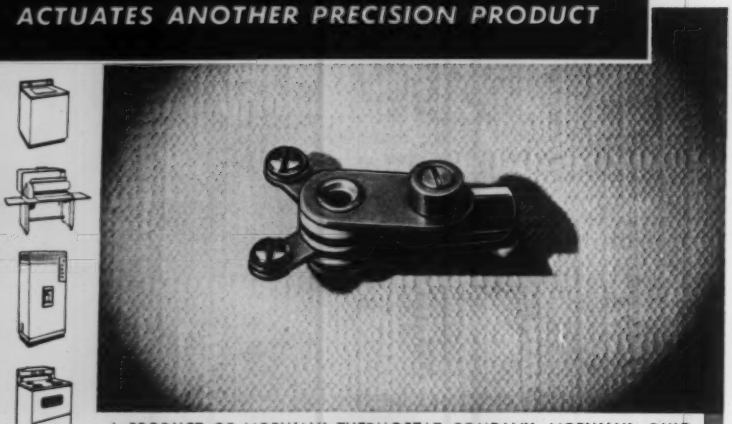
City.....Zone.....State.....

Circle 500 on Page 19

CHACE

THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT



A PRODUCT OF NORWALK THERMOSTAT COMPANY, NORWALK, OHIO

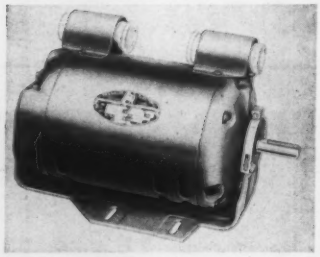
THE NorStat THERMOSTAT

NorStat Type A Thermostats (non-adjustable shown) provide make and break control of electrical circuits in appliances, heating and ventilating equipment, business machines, vending devices, manufacturing machinery and accessories. Which makes it quite likely you've unwittingly depended upon this hidden control in a percolator, beverage vendor, solder pot, furnace, sterilizer — or scores of other temperature actuated devices. The operating range is from 0° F. to 650° F. Accuracy is assured by NorStat's lubricated adjusting system insulator which rides on a raised dimple in the lower spring blade — and, of course, by the reliable actuating element of Chace Thermostatic Bimetal.

In order to produce a large volume of sensitive controls such as the NorStat Thermostat and *know* that the devices will continue to function without attention, the manufacturer must select his source of bimetal with care. He must be assured that the actuating element is of *the* alloys most suitable for his purpose, that tolerances are maintained always, that manufacturing processes and equipment are such as produce top quality, that the price is fair — quality considered — and that the integrity of the source is beyond question. Our more than a third of a century devoted exclusively to the development and production of precision thermostatic bimetal is his assurance of our qualifications to satisfy the most demanding.

So remember Chace when you, too, design for protection of life, valuable equipment, or for temperature actuation or indication. Dependable Chace Thermostatic Bimetal is available in over 30 types, in strip, coil or completely fabricated and assembled elements to your design. Send for our new 1958 booklet, "Successful Applications for Chace Thermostatic Bimetal," containing many pages of design data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.



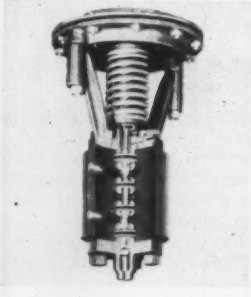
ing lubricant has been expended. Visual reservoirs mounted on each motor end bell contain a supply of proper lubricant. At a predetermined length of operation time, lubricant is discharged to bearing wick cavity, to a level required to feed bearing. As oil is used from wick cavity, it is continually replaced by fresh oil from reservoir. Motors are available in 1/3 to 1½-hp ratings in 56-frame, dripproof, open or totally enclosed construction. Applications include air conditioners, washers, furnace blowers, industrial machinery, business machines, and refrigerators. **Franklin Electric Co. Inc.**, Bluffton, Ind. J

Circle 684 on Page 19

High-Pressure Valves

utilize internal sleeve construction

Redesigned diaphragm-operated high-pressure valves for hydraulic or cold-water service have internal sleeve construction that provides shockless performance and leakfree shut-off with minimum maintenance. Valve seats are integral in a replaceable, hardened stainless-steel sleeve. Standard O-rings in molded Teflon backups provide a flexible seal between sleeve and valve body. Seating is not affected by minute deflections or breathing of valve body under high pressures. O-ring seals compensate for unavoidable body deflections and preserve constant concentricity of seat sleeve and stem.



Circle 501 on Page 19

Use 5 instead of 7...

save { space / weight / cost

***Money-saving fact:* A Gates Super Vulco Rope Drive delivers more HP per dollar invested than *any* standard V-belt drive.**

By using belts with 40% more horsepower capacity, you reduce sheave width and weight — save substantially in overall costs.

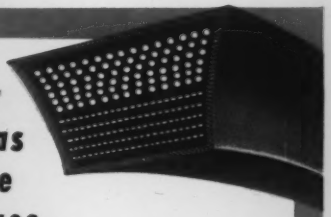
A wealth of drive data is always quickly available to you. Whether you need drive design service — or V-belts — or sheaves — just call your nearby Gates Distributor for a Gates V-Belt specialist.

Stocks carried in industrial centers throughout the world.

Gates Distributors are in the Yellow Pages

The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates — The Mark of *Specialized* Research



No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads ... reduce number of belts required ... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

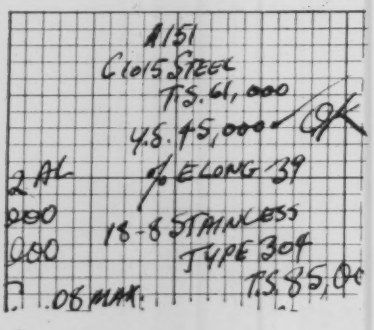
TPA 341

Gates Super Vulco Rope Drives

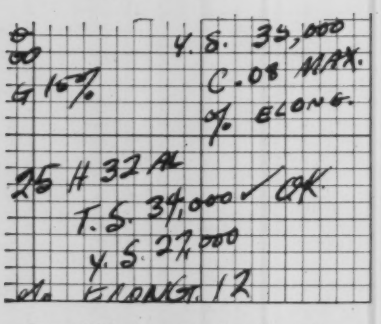
40% more Horsepower Capacity

Plus-tensile cold formed into stamped components

Only the stamping method of production offers such an unrestricted latitude of material selection. With stampings, strength can be designed right into a product or component part. It can be specified into the basic material and improved during the stamping process . . . it can be predicted, controlled and maintained. Strength in stampings can, in fact, be higher in proportion to weight than is possible in any other metalworking process.



All parts, pieces or units are designed around their predetermined end use. The end use pretty much dictates the material to be used in making the component. Only in stampings are the metal, finish and inherent characteristics of the part completely controlled and established beforehand by the design demands. With stampings, there is no need to sacrifice strength to gain other desirable properties. And in stampings, strength is achieved and not just approximated.



Durability is another quality inherent in every stamping. Because stampings are not fragile, they will not break or crack even when thrown out of line or dented by careless handling.

The resilience which characterizes stampings adds to their versatility in production, shipping, finishing and to the manner of their final assembly with other stampings, other component parts, to form a finished product.

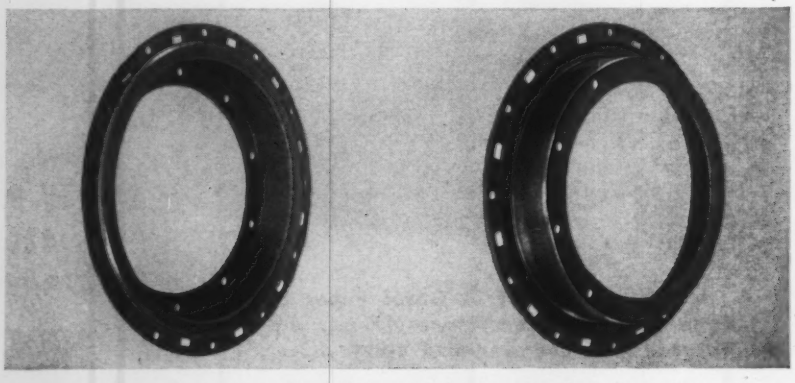
How to get permanent close tolerances without costly machining

Because the side housings of the Fawick Airflex Type E clutches are stamped to close tolerances, no costly machining is required before assembling.

This unique clutch puts all the load on torque bars which rest on the stamped housings. The clutch design takes full advantage of the inherent strength of the positioned steel.

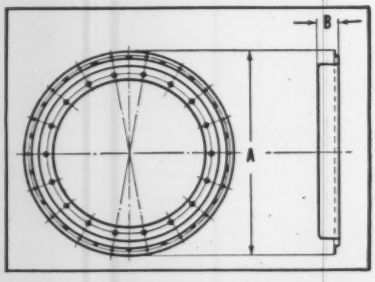
The Fawick clutch assemblies are used in a wide range of sizes for clutch and brake applications in heavy-duty original equipment.

Typical tolerances in the Fawick stamped housings are +.005" − .000", +.005" −.005", +.000" −.010". Special notes on shop drawings call for all holes equally spaced, within tolerances of plus or minus .005" while parallel surfaces are maintained. COMMERCIAL'S ability to meet such stiff stamping requirements reflects its skill and experience in handling unusual metal forming problems.



Close tolerances on pierced holes and slots insure perfect alignment of mating parts in final assembly.

Gang piercing provides the required dimensional and location accuracy of holes and slots without the cost of multiple drilling. Slotted openings with integral tabs are formed without metal fracture. The sharp bottom radii and straight sidewalls require a deep draw. Yet, close tolerances must also be maintained on these dimensions.



A	11⅞	13⅞	15⅞	18⅞	21⅜
B	2⅝	2⅝	2⅝	2⅝	2⅝
A	23⅞	26⅞	29⅞	33⅞	39⅞
B	2⅝	2⅝	3 11/32	3 11/32	3 29/32

These clutches in use on power shovels, locomotive cranes and other heavy-duty equipment, keep the load from slipping through friction. The housings stamped by COMMERCIAL withstand the load and the heat generated by the friction involved, yet maintain the alignment and accurate dimensions to which they are stamped.

If you have a design problem involving component parts, we may be able to suggest a practical and economical solution based on our 30 years experience in forming metals. Send details of your problem to Commercial Shearing & Stamping Company, Dept. S-34 Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

Circle 503 on Page 19

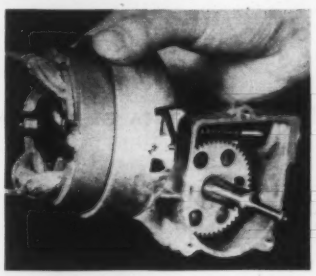
Valves are available for 4000 and 6000 psi service in sizes up to 3 in. NPT for 4000 and up to 2 in. NPT for 6000 psi. They are furnished as two or three-way units, normally open or normally closed. **Sinclair-Collins Valve Co.**, 454 Morgan Ave., Akron 11, Ohio. F

Circle 685 on Page 19

Gear Motor

for built-in, infrequent use

New gear motor is designed for built-in applications requiring few daily operations, such as appliances and the operation of garage doors, windows, and draperies. Rated at



1/15-hp, it operates with output of 390 rpm through a 25½:1 gear ratio, and can be adapted easily to a ratio of 51:1. Motor has cast aluminum case, steel shaft, bronze reduction gear, and bronze bearings. The single-stage worm gear is designated Type 5BA45. It is rated 115 v at 60 cycles. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 686 on Page 19

Voltage Regulator

for control of loads to 35 amp

Type EMT4104U voltage regulator automatically regulates fluctuating ac power lines to maintain constant output voltage regardless of line or load changes. Assembly is suited for applications requiring control of loads to 35 amp. Unit can either be used independently, or as a component with controls incorporated in an apparatus panel and remaining regulator elements installed remotely. Use of transistorized control circuit assures long life. Other characteristics include zero waveform distortion, low internal impedance, and virtually zero phase shift.

WHAT'S YOUR CLAMPING PROBLEM?
WITTEK
HAS THE ANSWER
Here is a selection from among the many different types and sizes of hose clamps designed and manufactured by WITTEK. Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the *exact* type and size clamp to do the job right! Let WITTEK help solve *your* clamping problems. Write today.
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WITTEK MANUFACTURING COMPANY
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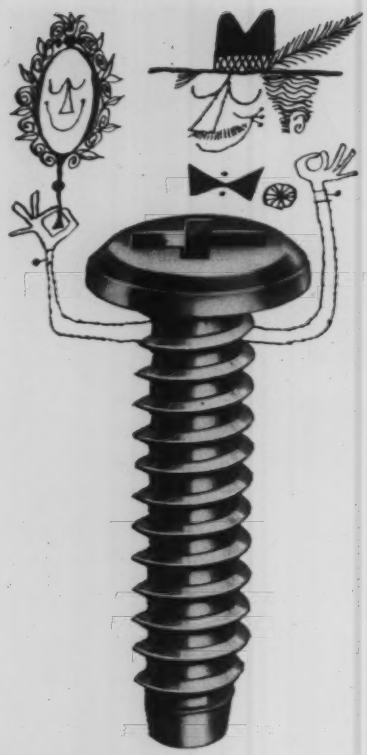
WM CO

Circle 504 on Page 19



FOR LASTING GOOD LOOKS...USE ALCOA ALUMINUM FASTENERS

Build lasting good looks—sparkling sales appeal—into your aluminum products with Alcoa® Aluminum Fasteners. Get perfect color match, avoid discoloring and weakening corrosion. Avoid ugly stains with bright, carefree Alcoa Aluminum Fasteners.

With Alcoa Aluminum Fasteners you are protected against galvanic and atmospheric corrosion. And they are readily available in all standard types and sizes at your local Alcoa distributor, or call your nearest Alcoa sales office. Look in the Yellow Pages of your telephone directory.

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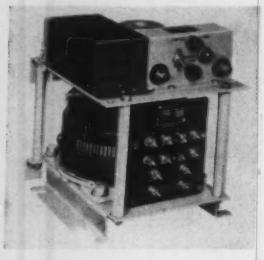
FREE FACTS, SAMPLES FREE FACTS

Aluminum Company of America
2244-H Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen: Please send complete specification data and samples of Alcoa Aluminum Fasteners.

Name_____
Title_____
Company_____
Address_____

Circle 506 on Page 19



Correction of voltage variations is accomplished in 0.1 sec per v from nominal. **Superior Electric Co.**, 83 Laurel St., Bristol, Conn. B

Circle 687 on Page 19

Cushion Valve

controls cylinder acceleration and deceleration

LCV cushion valve precisely regulates air flow and piston speed at any point in the stroke, permitting air cylinders to operate at maximum speed while providing controlled acceleration or deceleration as required. Unit utilizes a tapered valve stem, position of which in the bore determines rate of air flow or discharge from cylinder. Free-return check valve permits air return to

cylinder at full pipe capacity. Poppet position is established by a machine cam which actuates valve roller lever. Position and length of cam determines rapidity of piston deceleration or acceleration. Valve is available in six pipe sizes from $\frac{1}{4}$ to $1\frac{1}{4}$ in. **Numatics Inc.**, Highland, Mich. H

Circle 688 on Page 19

Miniature Solenoids

in push or pull models have long cycle life

Series 01 and 02 constant-duty miniature solenoids incorporate silicon-steel field and plunger assemblies to prevent residual magnetism and to lower eddy current and hysteresis losses. Shading coils are silver brazed

Now AVAILABLE "MECHANICS OF VEHICLES"

By
JAROSLAV TABOREK

A comprehensive study of the principles of vehicle motion from the designer's viewpoint. A complete reprint of the 14-part series appearing in MACHINE DESIGN.

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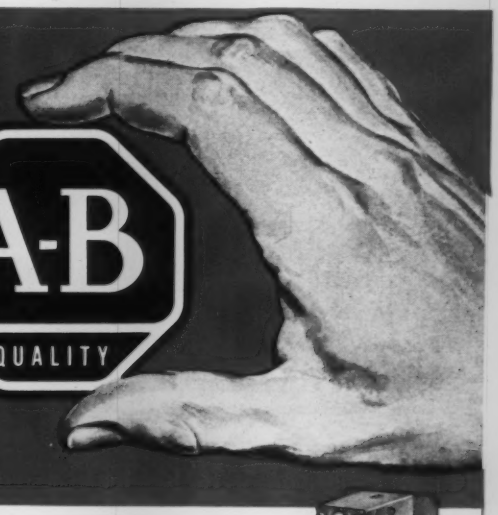
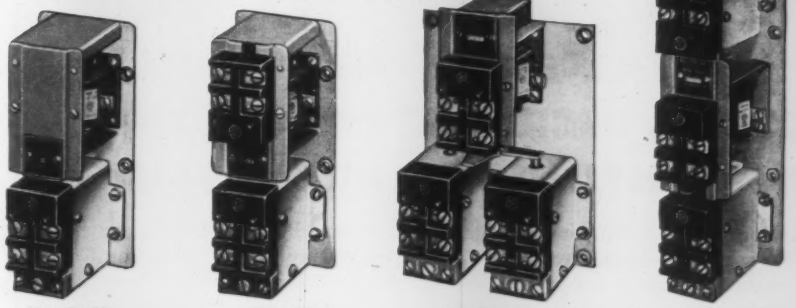
THE "SIGN" OF trouble free TIMING RELAYS!



Pneumatic Timing Relays

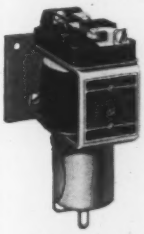
BULLETIN 849

These versatile timing relays are available in a variety of types for either "on delay" or "off delay." Delay time is adjustable from 1/20 to 180 seconds with an accuracy of ± 10%. Maintenance free silver alloy contacts. Additional auxiliary contacts easily added. A.C. or D.C. operation.



STANDARD UNIT | AUXILIARY CONTACTS ADDED | TWO TIMING UNITS | COMBINED ON-OFF TIMER

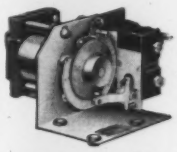
Fluid Dashpot Timing Relays



BULLETIN 848

For applications where reliability is more important than accuracy. As the viscosity of the silicone fluid does not vary with temperature, the timer's accuracy is ± 15% from −30°F to +120°F. Can be easily adjusted from 2 to 30 seconds.

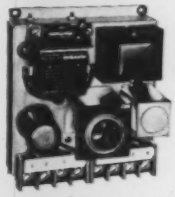
Motor Driven Timing Relays



BULLETIN 850

Driven by a Telechron motor, this timer alternately opens and closes two switch units. Made to provide 2, 3, 4, or 6 operations per minute on 60 cycles. Running and drift time on both contact units are easily adjustable.

Electronic Timing Relays



BULLETIN 852

An accurate and flexible A.C. timer, designed for frequent operation. Can be recycled rapidly over long periods. Time delay is dial adjustable over a range of 20 to 1. Repetitive accuracy ± 2%. Eight units provide time delay of 0.025 to 120 seconds.

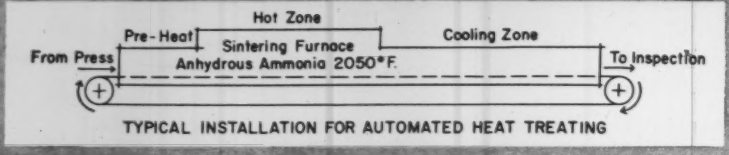
This broad line of timing relays carries the traditional Allen-Bradley trademark of *quality* that stands for trouble free operation. The rugged construction and maintenance free, silver alloy contacts have made them first choice among men in the field . . . engineers, consultants, and contractors. You just cannot go wrong when you specify Allen-Bradley control . . . by name!

Allen-Bradley Co., 1333 S. First St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Circle 507 on Page 19

Cambridge WOVEN WIRE BELTS



TYPICAL INSTALLATION FOR AUTOMATED HEAT TREATING

METAL-MESH BELTS CUT COSTS, INCREASE PRODUCTION IN CONTINUOUS PROCESSING

Continuous movement of metal parts, foods, chemical or ceramic products through practically any type of processing operation eliminates batch processing and manual handling for faster, more economical, more uniform production. Through wet, cold, hot or dry operations, Cambridge Belts give you all these advantages:

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, RUSTPROOF—Cambridge Belts can be woven from any metal or alloy, thus can be made impervious to damage from temperatures from sub-zero up to 2100° F., water, acids or caustic solutions.

OPEN MESH PROVIDES FREE CIRCULATION—process atmospheres pass freely through the belt for uniform processing of the parts in the load, process solutions drain through the mesh in a flash.

WOVEN WIRE CONSTRUCTION—has no seams, lacers or fasteners to wear or break—reduces maintenance costs and eliminates frequent belt replacements.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges or cross flights to hold product on belt during movement.

Whether you design machinery for your own use or for resale, your Cambridge FIELD ENGINEER can explain how the many advantages of Cambridge belts make automated processing practical and economical. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your operation. Call now. He's listed in the classified phone book under the heading "BELTING, MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

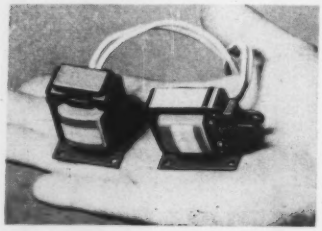
The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N, Cambridge 8, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Circle 508 on Page 19



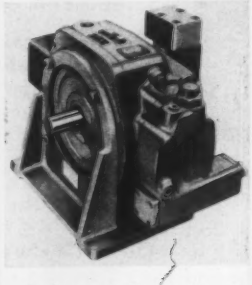
into the field assembly for improved quiet hold and long service life. Coil can be replaced when necessary instead of installing a complete solenoid. Series 01 produces 1¾ lb force at ½ in. stroke, and provides quiet hold at 4¾ lb force. Series 02 produces 2¾ lb force at ½ in. stroke, and quiet holds at 5½ lb force. Both series are available in push or pull models with vertical or horizontal mounting. **Detroit Coil Co.**, 2435 Hilton Rd., Ferndale 20, Mich. H

Circle 689 on Page 19

Hydraulic Pressure Pump

for working pressures of 200 to 1100 psi

New hydraulic pressure-unloading pump is designated type ANP. When adjustable preset pressure is reached on applied work, control hydraulically reduces pump volume by slip stroke to save input power, reduces heat, and hold pressure. Pump incorporates radial rolling

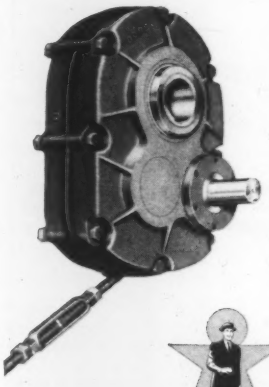


pistons, balanced flat valve for controlled oil film between working surfaces, one-piece cylinder and shaft, and large, antifriction bearings. It is supplied for either clockwise or counterclockwise rotation, and is built for face, right-angle bracket, or adapter mountings as well as standard or custom-built pump and motor-base reservoirs. Working pressure range is 200 to 1100 psi. **Oilgear Co.**, 1570Q W. Pierce St., Milwaukee 4, Wis. K

Circle 690 on Page 19

THERE'S QUALITY IN TORQUE-ARM

...AMERICA'S MOST WIDELY USED SHAFT-MOUNTED SPEED REDUCER



Extreme ruggedness and top quality are built into every detail of the Dodge Torque-Arm Speed Reducer—from the specially heat treated helical steel gears to the corrosion resistant semisteel housing. Broad demand has made it necessary to add sizes until today Torque-Arm is America's most complete (and most widely used) line of shaft-mounted speed reducers. Capacities range from 1 to 100 hp; output speeds from 12 to 378 rpm.

Torque-Arm is mounted on the driven shaft, in any vertical or horizontal position. It is anchored by the torque-arm fastened to any fixed object. No need for foundation, flexible coupling, sliding base. No lining up difficulties. The unit is driven through any V-belt drive. Savings up to 1/3 are possible and Torque-Arm's efficiency is high. It delivers 97% efficiency in double reduction models; and almost 99% in single!

Ask you local Dodge Distributor—or write us for bulletin.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

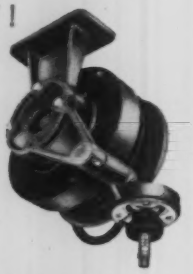
CALL THE TRANSMISSIONEER
—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the white pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

Circle 509 on Page 19

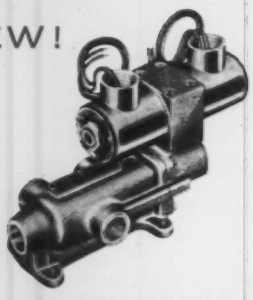
SCHRADER ADDS MORE NEW AIR CONTROL PRODUCTS TO GIVE YOU EVEN WIDER SELECTION

NEW!



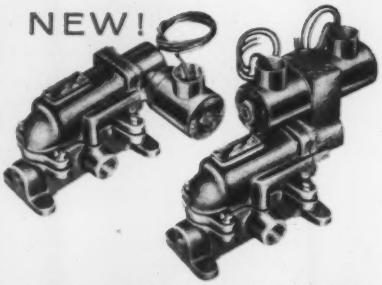
HOSE REEL FOR AIR TOOL SUSPENSION —Saves duplicate equipment and maintenance. Saves time on high speed production. Spring tension counterbalances air tools. Powerful spring automatically takes up tool.

NEW!



DOUBLE SOLENOID 4-WAY VALVES — Now double solenoid 4-way action available in full series . . . voltage-wise, port size, flow capacity. Permits longer dwell time in either position without continuous electrical energy.

NEW!

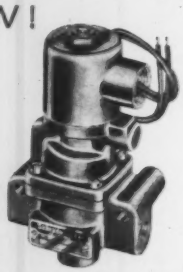


SUB-BASE SINGLE AND DOUBLE SOLENOID VALVES — Greater versatility. You don't have to disturb the piping for service. Reduces "down time" to absolute minimum. Complete series: voltages, sizes, capacities.

NEW!

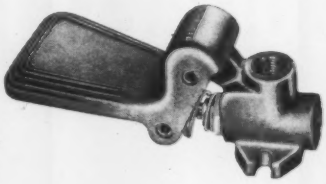
PILOT OPERATED SUB-BASE 4-WAY VALVES — Sturdy cast meehanite sub-base contains all ports for piping air. Permits removal of valve mechanism for service without disturbing piping. Complete new series!

NEW!



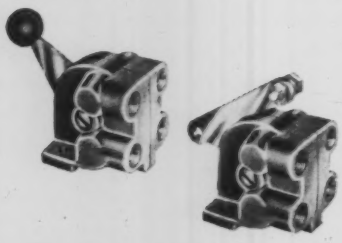
NEW! 3-WAY SOLENOID VALVES—Simple 3-way action available in full series—voltage, port sizes, flow capacities. By shifting pilot chamber head 90°, normally open changes to normally closed, and vice versa!

NEW!



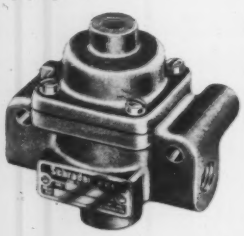
2- AND 3-WAY FOOT VALVES — With right angle ports. Give convenience and control with simplest installation. Mount directly on floor. ⅜" N.P.T. Sturdy, compact, and *versatile*. Take minimum space.

NEW!



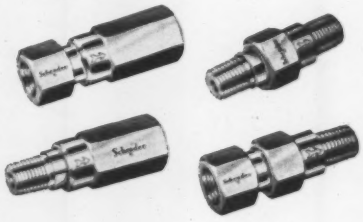
SLIDING SEAL VALVES FOR PIPED EXHAUST — Complete series! 2, 3, 4-way types. ¼" N.P.T. ports. Hand or mechanical lever. Compact, minimum working parts.

NEW!



3-WAY PILOT VALVES — Complete new line. Normally open or normally closed types. Ideal for single-acting cylinders. Simple, neat, sturdy. May easily be converted to solenoid.

NEW!



CHECK VALVES—Thread combinations now in complete series in spring-loaded check type. Pinpoint your needs. Amazingly compact, relative to large flow capacity. Capacity 35 cu. ft.

Schrader®
a division of SCOVILL

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

A. SCHRADER'S SON • *Division of Scovill Manufacturing Company, Incorporated*
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR PRODUCTS

Circle 510 on Page 19

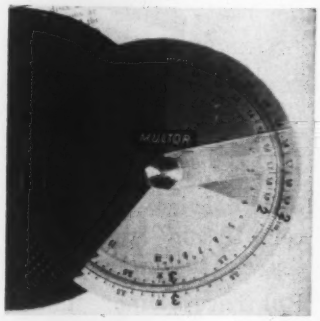
ENGINEERING
DEPARTMENT

EQUIPMENT

Pocket Calculator

is disc-type unit

Multor circular pocket calculator, consisting of two metal discs and a transparent-plastic sliding arm,



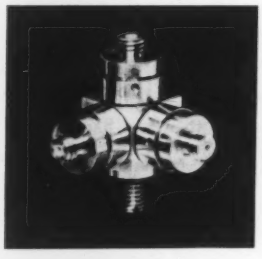
multiplies, subtracts, holds numbers, adds and subtracts percentages, and performs many other calculations instantly. Use of three separate colors speeds up calculation and prevents error in reading of answers. **R/B Crafters,** 1642 Fairmont Ave., Philadelphia 30, Pa. E

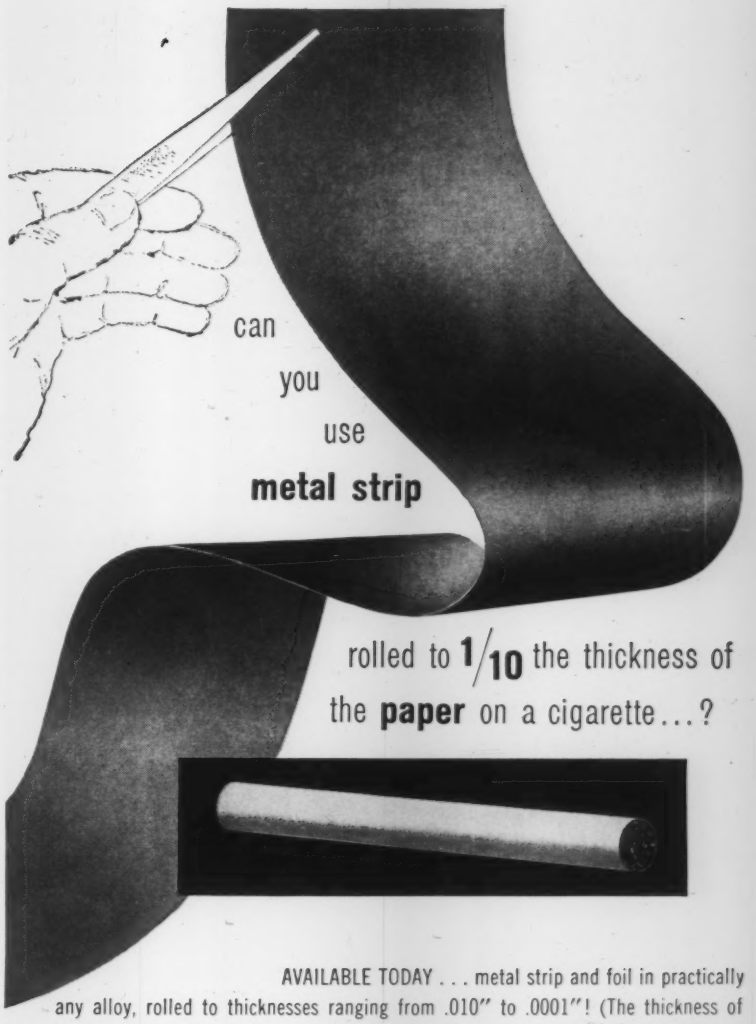
Circle 691 on Page 19

Accelerometers

measure in three directions

Line of triaxial accelerometers measures shock and vibration in three mutually perpendicular directions simultaneously. Standard 400-TX and miniature 500-TX accelerometers employ piezoelectric ceramics in compression for the sensing element to provide broad operational characteristics. Sensitivities up to 27 mv/g provide an acceleration re-





AVAILABLE TODAY . . . metal strip and foil in practically any alloy, rolled to thicknesses ranging from .010" to .0001"! (The thickness of cigarette paper is .00125".) The Precision Metals Division of Hamilton Watch Company is today producing these materials in quantities for either developmental work or production, meeting exact mechanical, magnetic and physical specifications.

Precision Metals Division, established by Hamilton to provide special metallurgical services in the manufacture of fine American watches, is a modern, completely integrated plant geared to precision production. Special alloys, developed to customer specifications, are also available in whatever form required.

With emphasis today on miniaturization and subminiaturization, designers and engineers are solving important problems with metal strip and foil from Precision Metals Division. To find out more about this unique service, write today for a copy of this new facilities book. Write on your letterhead to Dept. MD-8

Hamilton Watch Company

Precision Metals Division / Lancaster, Pennsylvania

Creator of the world's first electric watch

Circle 511 on Page 19

THERE'S A

WAYNE ROTARY TO PUMP ALL!

ROLLING GEAR DESIGN ASSURES HIGHER OPERATING EFFICIENCY

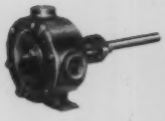
Viscous . . . volatile . . . fast . . . slow there's a Wayne Rotary Pump to pump products more efficiently and at lower costs. Wayne Pumps are of an improved type construction—gear-within-a-gear rotary pump. The positive seal and rolling contact of the tooth design assures pump service never before obtainable . . . less down time . . . fewer replacements. Write for new catalog.

RUGGED DUTY PUMPS

For installations where operating conditions are unusually severe. Capacities 35, 50, 70, 100, 200 and 300 gpm.

HAZARDOUS LIQUID PUMPS

Furnished with any type of drive—gear, V-belt or direct. Complete with relief valve. Listed under re-examination service of U.L.



STANDARD SERVICE PUMPS

Available in capacities of 3, 5, 10, 18, 20, 25, 35, 50 and 100 gpm. Ports right or left on all models. Straight through also on 3 and 5 gpm models.

THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Wayne PUMPS

Circle 513 on Page 19

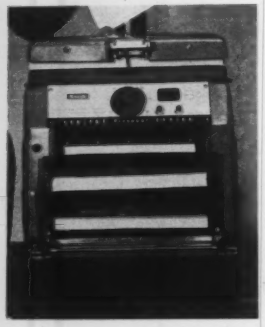
sponse from 0.03 to 40,000 g. Natural frequencies range from 20 to 35 kc for frequency coverage from 1 cps to 12 kc. Upper temperature limit is either 200 or 540 F. Units range in weight from 13 to 60 grams. **Columbia Research Laboratories,** MacDade Blvd. & Bullens Lane, Woodlyn, Pa. E

Circle 692 on Page 19

Copying Machine

copies material up to 10 x 16 in.

New Verifax Viscount copier has an improved paper-feed assembly and new trimmer guide assembly for 10-in. paper. Unit copies ma-



terial from business-card to 10 x 16-in. size. Copier incorporates a timer which compensates for changes in electrical voltage. **Business Photo Methods, Eastman Kodak Co.,** Rochester 4, N. Y. F

Circle 693 on Page 19

Drafting Film

has tensile strength of 20,000 psi

Ageproof drafting film, made from Mylar base, is tearproof, completely fungus-resistant, and impervious to perspiration, water, and soft-drink spots. It has tensile strength of 20,000 psi, tensile modulus of 550,000 psi, and flex-life of 20,000 cycles. Transparent, fiberfree structure insures sharp, legible reproduction. Film is also available with diazo and photo-type sensitized surfaces, providing an efficient, economical way of obtaining print copies with the properties of the original film. **Eugene Dietzgen Co.,** Dept. M-1, 2425 N. Sheffield Ave., Chicago 14, Ill. J

Circle 694 on Page 19

VIGILANCE

The final victory over cancer will come from the research laboratory.

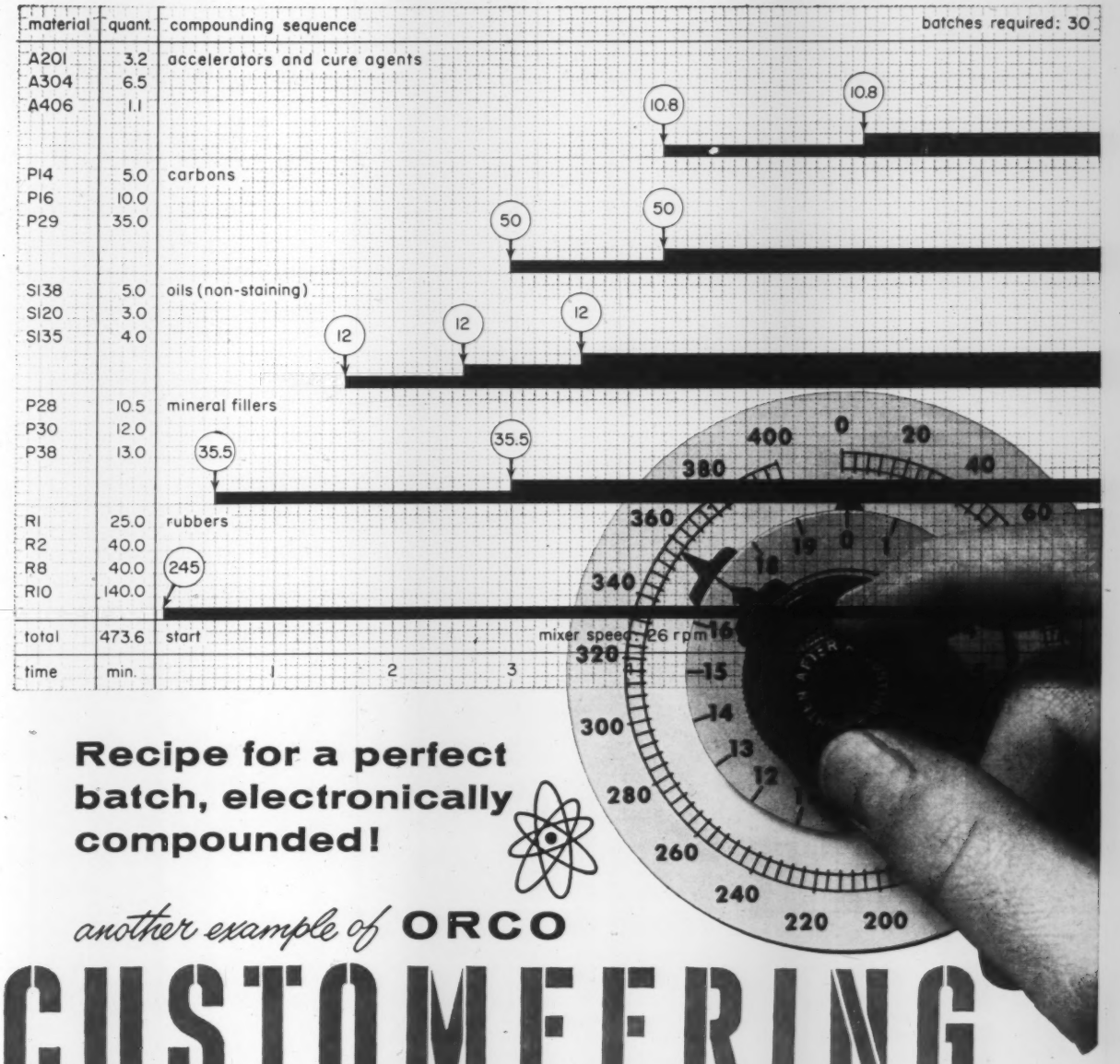
But there is a more immediate victory at hand today. Many cancers can be cured when detected early and treated promptly. *Vigilance* is the key to this victory.

There are certain signs which might mean cancer. Vigilance in heeding these danger signals could mean victory over cancer for you:

1. **Unusual bleeding or discharge.**
2. **A lump or thickening in the breast or elsewhere.**
3. **A sore that does not heal.**
4. **Change in bowel or bladder habits.**
5. **Hoarseness or cough.**
6. **Indigestion or difficulty in swallowing.**
7. **Change in a wart or mole.**

If your signal lasts longer than two weeks, go to your doctor to learn if it means cancer.

AMERICAN CANCER SOCIETY



Recipe for a perfect batch, electronically compounded!

another example of **ORCO**

CUSTOMEERING

Typical of the advanced techniques at Ohio Rubber is the electronically controlled mixing of rubber and rubber-like compounds. Precise mixing of rubber polymers and compounding ingredients—according to exacting formulas—can be automatically assured at ORCO through electronic control of every step of each batch mixing operation.

Here is just another reason why Ohio Rubber is widely recognized as an outstanding producer of "customeered" parts from rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl—whether molded, extruded or bonded to metal.

From components weighing less than a gram to parts of over 73 lbs., complete ORCO facilities for design, production, as well as electronically controlled mixing, are prepared to handle your most exacting rubber and vinyl component requirements. Let ORCO CUSTOMEERING help you with your very next component problem.

Send for free booklet "Component CUSTOMEERING rubber and vinyl parts".

ORCO

THE OHIO RUBBER COMPANY

WILLOUGHBY, OHIO

A DIVISION OF THE EAGLE-PICHER COMPANY

(Advertisement)

How to Design Economical Parts to Withstand Cyclic Stress

Many machine parts are subjected to repeated stress under service conditions. Cyclic loading of this sort frequently imposes a difficult design problem. A metal cannot withstand a repeatedly applied stress as large as the load which it can stand if that load is applied steadily. Thus fatigue limit, rather than tensile strength, or yield point, becomes the most important factor in design and metal selection.

Fatigue Limit and Fatigue Ratio

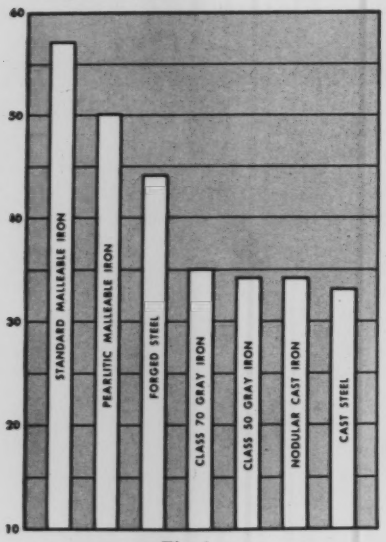


Fig. 1 . . .
Average fatigue ratios, unnotched.

The fatigue limit of a material is the limiting value of the stress below which it can presumably endure an infinite number of stress cycles. Fatigue limit is determined by applying repeated or reversed cycles of stress in tension, compression, transverse loading, or torsion. Most tests are stopped at ten million cycles if failure has not occurred, and the life of the specimen is then said to be indefinite.

The fatigue or endurance ratios (ratio of fatigue limit to tensile strength) of various metals are shown in Fig. 1. As indicated, the susceptibility of both ferritic and pearlitic malleable irons to progressive fracture is much less than in many other metals. This is attributable to the ferritic matrix which so completely envelopes the temper carbon nodules in the structure.

Fatigue Characteristics Under Notch Conditions

Whenever design requirements involve radical section changes or sharp internal corners, low notch sensitivity in the metal being used is extremely valuable.

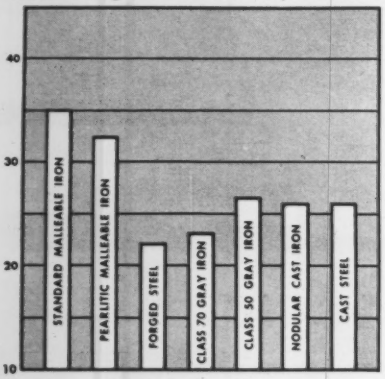


Fig. 2 . . .
Average fatigue ratios, notched.

Fig. 2 shows average notched fatigue ratios for various metals. Again, the malleable irons are far superior. The fatigue ratio and notch fatigue strength of malleable iron castings become even better by shot peening highly stressed areas.

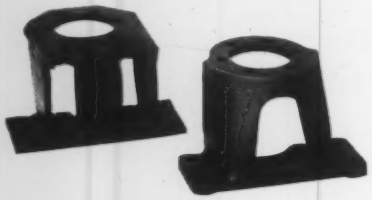


Fig. 3 . . .
Example of high fatigue resistance.

Good use of malleable's excellent fatigue strength is illustrated in this pump mounting bracket for an agricultural sprayer. The pump is bolted on the top and the drive shaft runs through the large center hole causing continuous cyclic loading. Conversion from a five part weldment with drilled holes to a malleable casting resulted in an increase in fatigue resistance at lower cost. Other advantages are better appearance, elimination of machining and a weight reduction of 22%.

Malleable iron's superior fatigue resistance is just one of the many excellent qualities that help you do a better job with malleable.

Write for Data Sheet

Comparative information on fatigue characteristics of various metals is available in handy data sheet form for use by design engineers and materials specifiers. For your copy write to **The Malleable Founders Society, 1800 Union Commerce Building, Cleveland 14, Ohio,** or contact any member foundry.

THE ENGINEER'S Library

Recent Books

Differential Equations. *By Forest R. Moulton; 395 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 920 Broadway, New York 10, N. Y., $2.00 per copy.*

This volume outlines procedures for solving only ordinary differential equations. Although practical applications are used as examples, principles of solving these equations are emphasized.

Oral Communications. *By Robert S. Casey, 199 pages, 5¼ by 7¼ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $4.50 per copy.*

Methods of effective speaking for technical men are presented in this book. It covers topics such as composition, organization of material, delivery of formal and impromptu speeches, and the use of mechanical aids, such as recordings and slides.

The Solid State for Engineers. *By Maurice J. Sinnott; 522 pages, 6 by 9 in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y., available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

Set forth in this book are the basic principles which underlie the behavior of solid materials used in engineering. Mechanical, thermal, electronic, magnetic, and optical properties are given for many solid materials.

Mechanics, Wave Motion and Heat. *By Francis Weston Sears, professor of Physics, Dartmouth College; 664 pages, 6 by 9 in., clothbound; published by Addison-Wesley Publishing Co., Inc., Reading, Mass.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

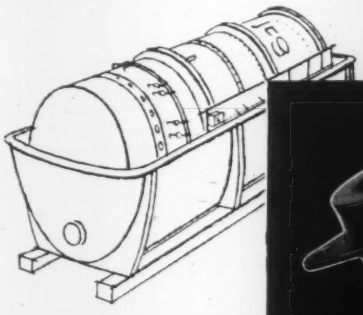
Presented in this book are the physical principles of mechanics, wave motion, and heat. It covers such topics as damped and forced

Circle 515 on Page 19

Have you vibration control problems like this?

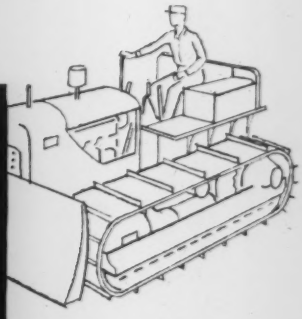
☐ **SOFTEN TRANSPORTATION SHOCK**

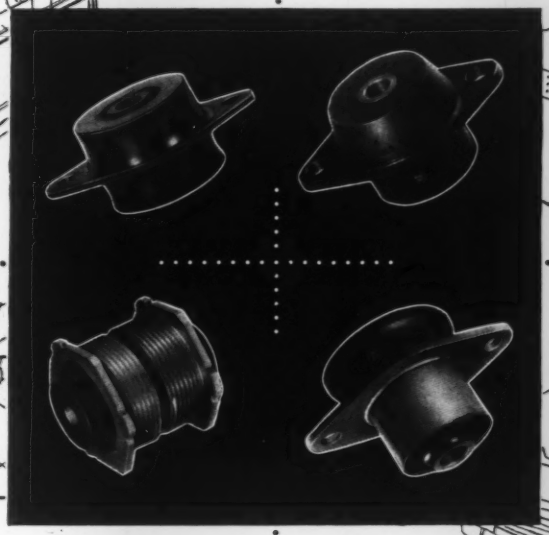
MB Type 1812D83 mounts protect engines in shipping cans. Even for a 3-ft. drop, they restrain displacement and maximum "g" to which engine could be subjected. They also provide a natural frequency to the mass that avoids resonance and amplified vibration in transit.

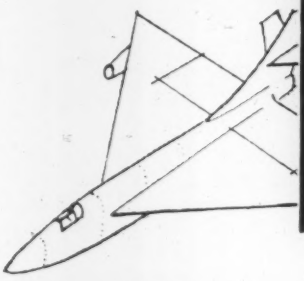


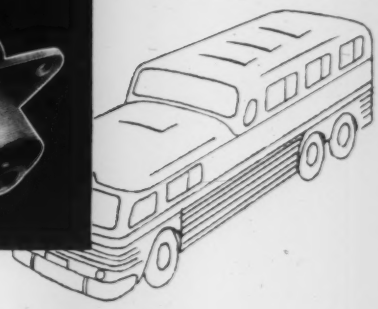
☐ **ISOLATE RUGGED RIGS**

MB Type 5 mounts stand up and successfully isolate engines of even tractor dozers. The tough service conditions prove the efficiency of this original mount designed with equal spring rate in all directions, and with ability to snub damaging overloads.









☐ **CONTROL OVER FULL FREQUENCY RANGE**

MB ISO-DAMP* mounts do what a conventional isolator cannot. They isolate at both low and high frequencies. Protecting the precision of airborne sighting mechanisms, they not only have the required softness, but also a damping mechanism that restricts resonant build-up to under 3.5 to 1 in any direction. *T.M.

☐ **MORE MOUNT MILEAGE**

MB ISOMODE® mounts break endurance records. Despite heat, road shock and hard operating conditions in bus service, engine mounts removed for critical inspection after 132,000 miles were still good. To such durability add the superior vibration isolation afforded by a mount that controls vibratory motion in all directions.

MB concentrates on standard mounts which are actually in the special performance class. If you have a problem, avail yourself of our 20 years of experience. Send for Bulletin 616A which tells more.

MB manufacturing company 1056 State Street New Haven 11, Conn.

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harmonic motion, hydrodynamics, dimensional analysis, black-body radiation, laws of thermodynamics, and wave motion in general.

The Presentation of Technical Information. *By Reginald O. Kapp; 147 pages, 5 by 7½ in., clothbound; published by and available from The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., $2.95 per copy.*

Prepared as a guide to technical writing, this book outlines procedures for presenting information in an imaginative and free-flowing style. Specific pointers include the use of repetition, breathing spells, metaphors, bridges of logical reasoning, and proper application of qualifying statements.

Mathematical Tables. *By Herbert Bristol Dwight; 217 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 920 Broadway, New York 10, N. Y., $1.75 per copy.*

Besides tables of elementary functions, this book contains tabular listings of higher-mathematical relations. These tabulations include exponential, hyperbolic, and Bessel functions, as well as integrals, factorials, and binomial coefficients.

Mathematics and Logic for Digital Devices. *By James T. Culbertson; 224 pages, 6 by 9 in., clothbound; published by and available from D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J., $4.85 per copy postpaid.*

This book presents a study of the mathematical reasoning essential to the understanding, programming, operation, and design of digital computers.

New Standards

American Standards, Power Circuit Breaker Control, C37.11-1957. *14 pages, 8½ by 11 in., paperbound; published by and available from American Standards Association, 70 East 45th St., New York 17, N. Y.; $0.80 per copy.*

Basic requirements for power circuit breaker control schemes are established in this American Standard. It is intended to reduce the multiplicity of special control schemes specified.

Zinc coating holds tight on sheets drawn 4½ in. deep

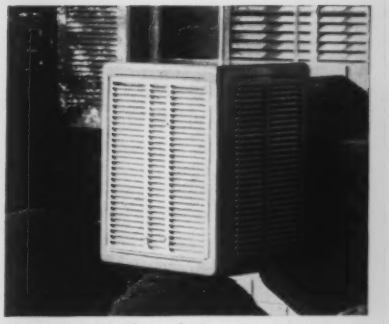
Here you see a part of the housing of a room air-cooler. The cooler is of the evaporative type, and the ever-present moisture makes rust a continual threat. For this reason the manufacturer decided to make the housings of rust-resisting galvanized sheet steel, with an enamel finish baked on. But the whole idea depended on the ability of galvanized steel to be deep-drawn without faulting the zinc coating.

RIGHT DUCTILITY AND STIFFNESS

A trial showed that Bethcon galvanized sheets would successfully take the draws, some of which were 4½ in. at one blow. The reason for this success lies in the fact that Bethcon is galvanized by our unique continuous process, a process which does two wonderful things to a Bethcon sheet:

1. It bonds the zinc so tightly to the sheet that the zinc won't flake off even in severe forming operations.
2. It imparts to the sheet an ideal blending of ductility and stiffness, so that deep-draws can be made without sacrificing rigidity in the product.

Industry is discovering all sorts of interesting ways in which Bethcon continuously galvanized sheets can help make products better, more economically. Where you need the strength of steel, coated for corrosion-resistance, you're likely to find Bethcon a new answer to your problem. Why not discuss it with a Bethlehem representative?



This cooler is in wide use for homes, trailers, industrial and public buildings. For maximum rust-protection, unit is cased in Bethcon galvanized sheet steel, primed with zinc-chromate and finished in baked enamel.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
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BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 518 on Page 19

ACP ALODINE* — its properties and functions in protecting aluminum alloys and bonding paint to them

By ALFRED DOUTY: Technical Director, AMCHEM PRODUCTS, INC.

Aluminum protects itself against corrosion by a coating of its own oxide. This adds weight, but does not provide complete protection. Even commercially pure aluminum in clean air at ordinary room temperature oxidizes indefinitely.

The use of adherent inorganic protective coatings on aluminum has long been recognized as efficacious in reducing corrosion rate and prolonging paint life. Since aluminum oxide tends to be protective, it is natural that the most intensive early efforts in this direction should have involved processes for improving the properties of the naturally occurring oxide coating. Anodizing, or electrochemical oxidation, although it is one of the most effective of such methods, is rather costly and time consuming.

ALODINE†

Early in 1945 a new chemical process was devised for producing an amorphous phosphate coating on aluminum. Its simplicity, speed and economy and the unique properties of the coating have resulted in wide commercial acceptance. It is called the Alodine Process.

Some idea of the effectiveness of the Alodine coating on unpainted 3S Grade aluminum may be had from Fig. 1. All panels were removed from the salt spray cabinet after 300 hr. except the Alodized and anodized panels, which were continued to 800 hr.

Organic protective and decorative coatings, such as paint, likewise require a corrosion-retarding undercoating of the kind produced by Alodine to achieve their maximum life and adhesion.

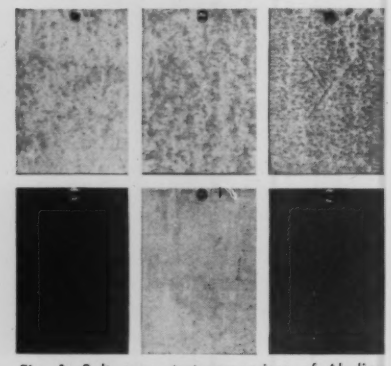

Fig. 1. Salt spray test comparison of Alodine with other surface treatments on unpainted aluminum. (Left to right, top row) solvent wiped —300 hr.; alkali cleaned—300 hr.; phosphate coated—300 hr. (Bottom row) chemically oxidized—300 hr.; anodically oxidized—800 hr.; Alodized—800 hr.

The effect of the Alodine coating in retarding underpaint corrosion is shown in Fig. 2. The Alodized panel was given a top coat only. All other panels in the series were primed after the surface treatments with a regular automotive product, baked, given a surface coat dry-scuffed with sandpaper as per standard automotive practice, and then finished with a regular black baked top coat. The panels were removed from the salt spray after failure of the paint film had set in.

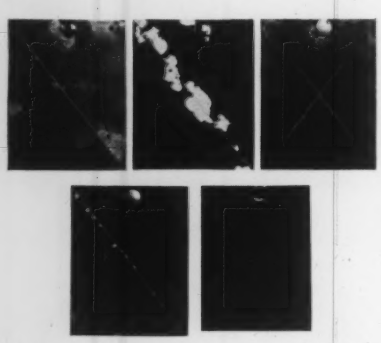

Fig. 2. Salt spray test comparison of Alodine with other surface treatments in retarding underpaint corrosion. (Left to right, top row) alkali cleaned and phosphoric acid dipped—300 hr.; phosphoric acid, solvent cleaned—300 hr.; zinc phosphate coated—400 hr. (Bottom row) anodically oxidized—3000 hr.; Alodized—3000 hr.

COATING CHARACTERISTICS

The coating produced by this new process is an amorphous metallic phosphate, dense, rather hard, and apparently nonporous. Unlike most oxide films, it is nonabsorptive and cannot be dyed or stained. Sealing in hot water or salts has no apparent effect. It differs markedly in appearance from previously known phosphate coatings, as shown in Fig. 3.

Electrical Resistance. Very little information is available at the present time on the electrical properties of the coating, but it is known that resistance increases very rapidly with thickness and as a result coatings normally produced offer extremely high resistance.

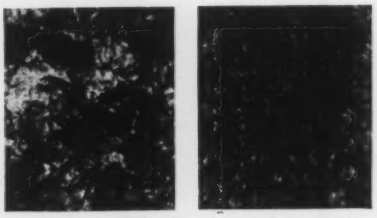

Fig. 3. (Left) conventional phosphate coating on aluminum; (right) Alodine coating produced in 3-min. immersion, rinsed and air dried. Magnification 500 diam.

Weight and thickness. Generally speaking, the weight of the amorphous phosphate coating increases with processing time, bath strength, and bath temperature. It is interesting to note that the increase becomes less and less pronounced as the temperature increases and actually reverses itself into a sharp decline between 130 and 140°F.

Adhesion. The original purpose in development of this process was to improve adhesion of the paint to aluminum surfaces and thus lengthen their overall life. Only later was it discovered that the film itself provides corrosion resistance.

Resistance to Bimetallic Corrosion. Since it has very high surface resistance, the coating, as would be expected, offers good resistance to bimetallic or galvanic corrosion. Test samples are available to illustrate the insulating effects.

We present here a general and by no means complete, report on ACP Alodine—its properties and uses in protecting aluminum alloys. Your ACP sales representative can give you a much fuller story. Or write us at Ambler.

*Alodine is a registered trademark of Amchem Products, Inc.

†Since the introduction of Alodine amorphous phosphate coatings, ACP has developed a complete line of Alodine amorphous chromate coatings for superior corrosion resistance.

Amchem Products, Inc. Ambler 44, Pa.

Formerly AMERICAN CHEMICAL PAINT COMPANY

CHEMICALS ACP PROCESSES

DETROIT, MICH. • ST. JOSEPH, MO.
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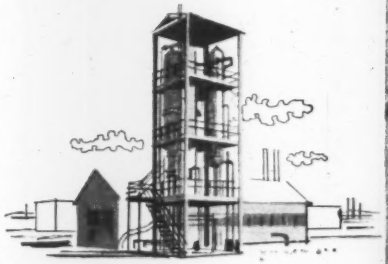
New Chemical Horizons for Industry and Agriculture

Pilot plant reactor shell *after 2000 hours service. Note corrosion on stainless steel shell and flange, while titanium liner shows no corrosion effects. Right: Titanium dip-tube after 2000 hours operation remains free of corrosion damage.*



In high-temperature nitric acid service...

TITANIUM WINS TOUGH 2000-HOUR CORROSION TEST

A large petrochemical company recently tested titanium versus other metals in high-temperature nitric acid service. 6% to 10% concentrations were handled in a pilot plant reactor at temperatures between 300° to 400°F.

Above you see dramatic proof of titanium's performance in this punishing service. After 2000 hours, the reactor's titanium liner and dip-tube showed no corrosion effects, while the stainless steel shell and flanges were badly corroded.

Further corrosion-rate tests were made by immersing test coupons of various metals in the reactor for 40 hours. Again, test results proved titanium's outstanding corrosion resistance (see chart at right).

Want more information? Write for bulletin on Corrosion Resistant Properties of Titanium.

CORROSION RATE TEST
Conditions: 375° F, 300 psig, 6% nitric acid

Material	Corrosion Rate mils/yr
Titanium	nil
347 stainless steel	59
304 stainless steel	170
310 stainless steel	274
410 stainless steel	402
309 stainless steel	485
Nickel-Chrome Alloy	20,500

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

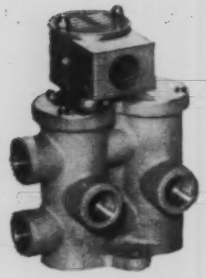
Integrated producer of Titanium • Zirconium • Special Metals

Circle 520 on Page 19

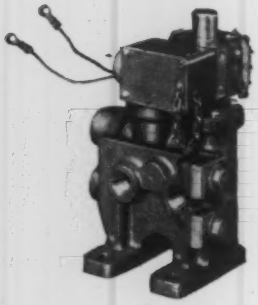
BY A MERE COIL CHANGE

Crescent® Valves are adaptable to

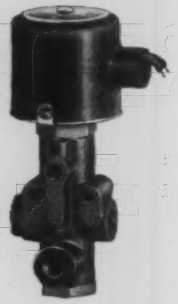
ANY VOLTAGE



Standard 4-Way



J.I.C. Type 4-Way



Standard 3-Way

® 4-Way and 3-Way Solenoid operated, pilot controlled valves for Air, Water and light oil to 150 P.S.I., products of Crescent Valve Co.

NO COIL BURNOUT

because a generous power margin, short solenoid travel and pilot operation combine to prevent overheating and overloading. Note that these valves are accepted and used in automotive plants where assembly line production does not permit coil or valve failure.

LONG SERVICE LIFE

Main valve design is aimed at extremely long trouble free service. Resilient seats are tight sealing and are not affected or damaged by dirt or grit because they are of a self scavenging design. Witness their superior performance in such severe service as operating hopper doors on cement batching equipment and in other dusty environment.

INTERCHANGEABILITY

Solenoids and pilot sections are interchangeable from one valve size to another, minimizing spare parts requirements. Adaptation to any practical voltage is achieved by a simple coil change.

Speed of response, speed of installation and dependable leakproof operation year in and year out are responsible for the increasing switch to Crescent valves on production machinery where time is money.

Write for Catalog 6-C

CONTROL VALVE DIVISION

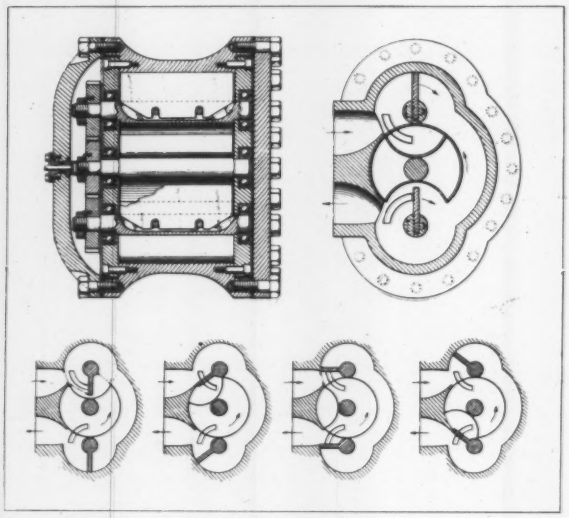
Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY

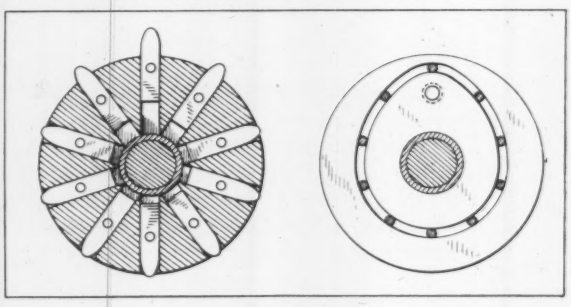
Patents

Positive-Displacement Hydraulic Unit



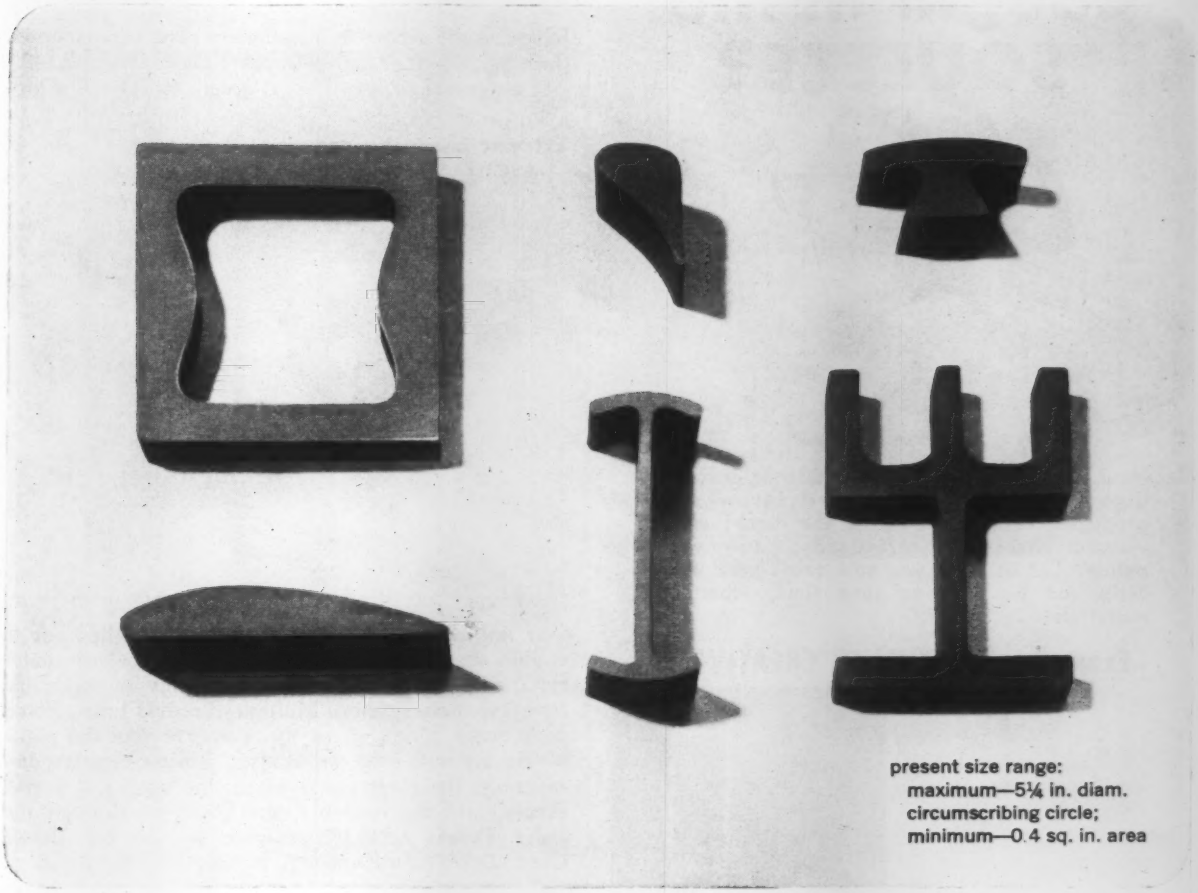
Smooth, constant flow is provided in a rotary, positive-displacement hydraulic unit by arc-shaped ports which bypass fluid at positions where the rotors tend to cause compression or vacuum. Rotation of the three moving parts is synchronized by a gear train. Sealing between adjacent moving parts, and between rotors and the casing, is provided by close clearances and by surface serrations which act as labyrinths. *Patent 2,835,204 assigned to Liquid Controls Corp., North Chicago, Ill., by George B. Richards.*

Retracting-Tooth Sprocket



A number of pins, reciprocating in radial grooves in a rotating plate, engage perforations in sheet passed over or around the plate to insure alignment and uniform feed of the sheet at the point where the pins are the maximum distance from center. Smaller pins, projecting from a side of the sprocket pins which are square in section, produce the reciprocating motion by

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels



present size range:
maximum—5¼ in. diam. circumscribing circle;
minimum—0.4 sq. in. area

- 321 Stainless
- 410 Stainless
- 405 Stainless
- SAE 1020
- 304 Stainless
- SAE 4340

Here's how highly intricate steel extrusions from Allegheny Ludlum help you cut costs

Allegheny Ludlum Extrusions can help you cut costs, save money. If you are now rolling, casting or machining steel parts like these, consider the cost-cutting features inherent in extruding metal, already proved by non-ferrous extrusions during the last 10 years.

A-L high-quality Steel Extrusions can save you money on four very important counts. (1) Orders are taken in quantities as small as 40 pounds. No large tonnage rolling requirements. (2) Charge for die design is low—under $200. No expensive rolls to cut. (3) Machining costs are slashed to a minimum; there's no waste of material. (4) Extruding saves time from the order to availability of finished parts.

There is no limit to what steels can be extruded. Allegheny Ludlum works everything from all stainless grades to carbon and electrical steels, high temperature alloys, nickel alloys and even metals such as zirconium.

Prove to yourself that extruding steel can save you money. Write for Allegheny Ludlum's 12-page technical bulletin, full of process explanations, material properties, design tips, etc. Or contact your nearest A-L office for technical assistance.

Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pennsylvania. Address Dept. MD-8.

WSW 7120

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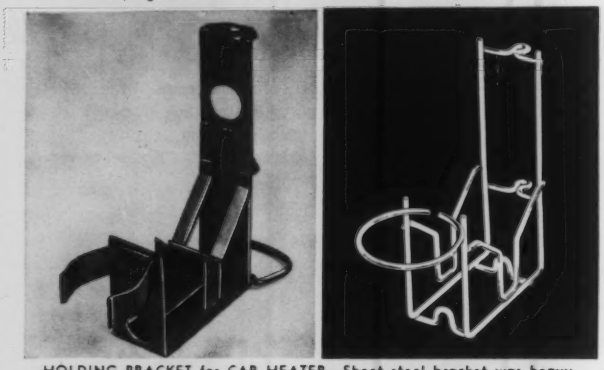
EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Caught in the SQUEEZE?

Now, more than ever, we want to help you reduce costs, save materials and improve your products. Learn more about the money saving ways of Titchener Wire/Strip design and fabrication. Let us show you how and where Wire/Strip can be used to save time, labor and materials.

Example of TITCHENER CREATIVITY



HOLDING BRACKET for CAR HEATER—Sheet steel bracket was heavy, expensive and unattractive. Edges were sharp. The Titchener welded Wire bracket reduced weight, cut costs and improved appearance. Tool costs were lowered and use of wire eliminated sharp edges.

Wire / Strip has much to offer . . . strength, lightness, resilience and decorative features. Use our complete Wire/Strip design and manufacturing facilities as part of your production team. Send us a sketch, drawing or the actual part; better yet, bring it with you to our modern plant. We'll show you what we can do. Consult us in confidence — there's no obligation.

Write for **FREE**
Wire/Strip book(s) today!

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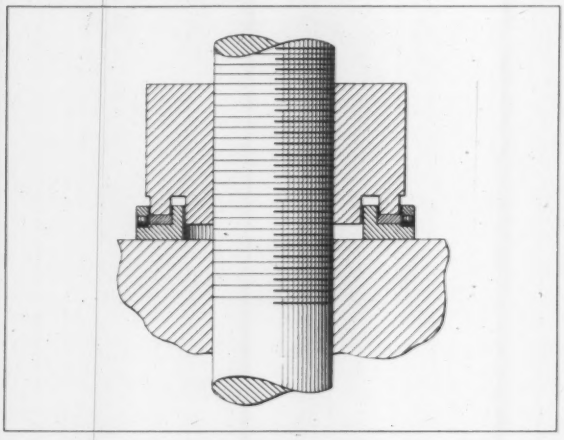
- ☐ "Use of Wire Construction in Product Design"
- ☐ Please have a Titchener Field Engineer call

E. H. TITCHENER & CO.
Dept. 3312, 67 Clinton St., Binghamton, N. Y.

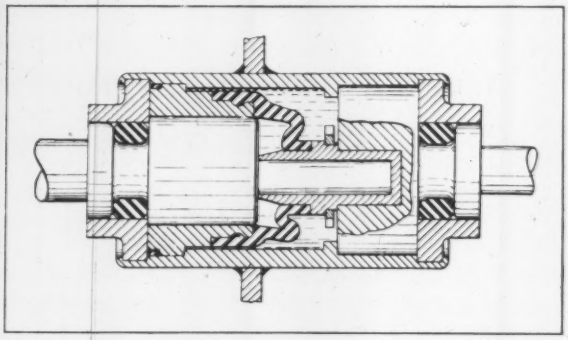
following the groove in a stationary plate cam mounted flush against the rotating sprocket plate. *Patent* 2,842,247 *assigned to Uarco Inc., Chicago, by John E. Euth.*

Extreme-Load Washer

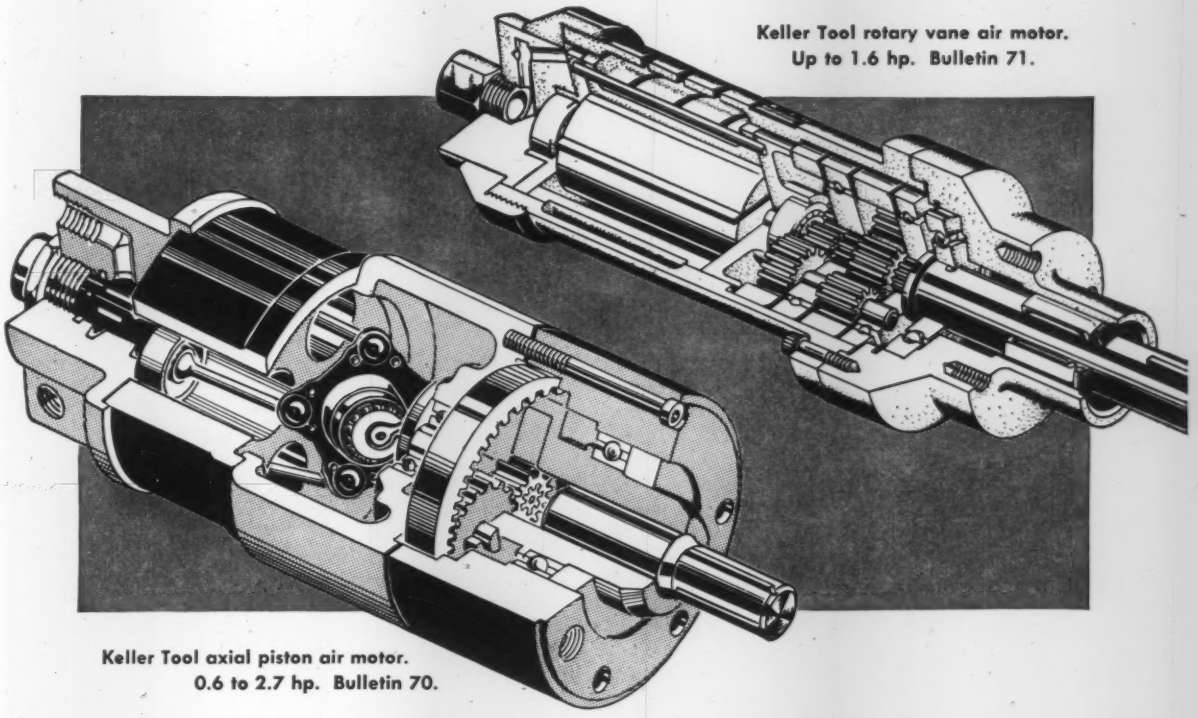


A fusible metal insert in a washer is melted out to enable disassembly of a threaded connection under static tension so great that disassembly is impossible by conventional means. Multiple threaded holes, closed by setscrew plugs, pierce the washer rim in the plane of the insert. To relieve tension, and thus enable disassembly, the plugs are removed, the washer is heated evenly, and the molten insert flows out through the holes. *Patent* 2,835,158 *assigned to General Motors Corp., Detroit, by Emmett A. Bartlow.*

Sealed Shaft Connection



An eccentric pin in extension of a drive shaft transmits rotation to a second shaft, coaxial with the first, in a sealed housing designed for stationary mounting in a barrier between two fluid chambers. A cylindrical cap, fitted over the pin and into an enlargement on the driven shaft, travels with the pin but does not rotate about its own axis. Motion of the cap is accommodated by a tubular seal fitted tightly to the cap and a drive-side bearing. The seal divides the housing into two chambers entirely filled with oil which lubricates moving parts. *Patent* 2,837,926 *assigned to Haydon Switch Inc., Waterbury, Conn., by Theodore Y. Korsgren, Sr., and Frank Stelma.*



Keller Tool rotary vane air motor.
Up to 1.6 hp. Bulletin 71.

Keller Tool axial piston air motor.
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Air power is idea power . . .

when your design calls for motors with these features:

High starting torque
Reversibility without power loss
Variable speed, easily controlled
Cool operation
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Consistent torque output
Non-sparking characteristics
Thrust and axial spindle loads
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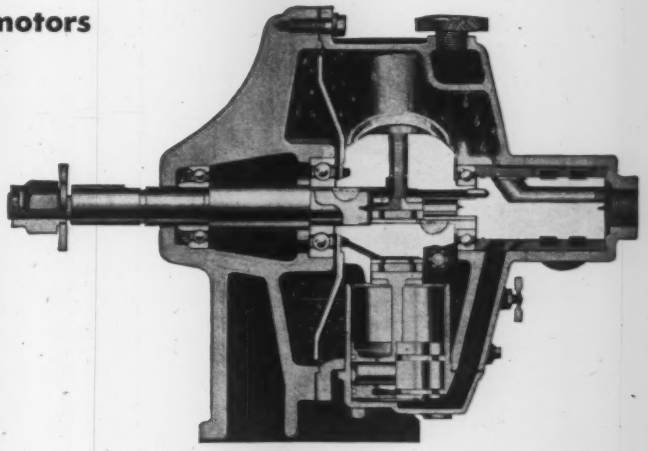
Output from ½ to 16 hp.

AIR MOTORS are your answer
Write for detailed bulletins.



Gardner-Denver five-cylinder radial
air motor. 3 to 16 hp. Bulletin AM-1.

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GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois
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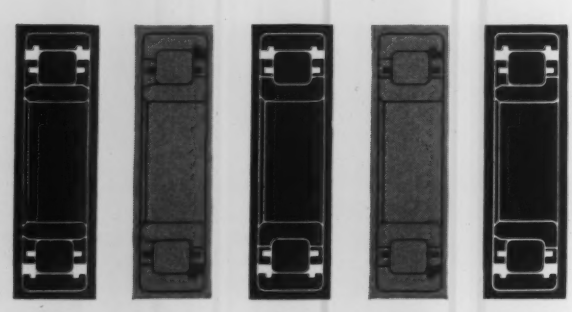
Circle 524 on Page 19

The Type UR-E Tru-Rol segmented-retainer bearing illustrated above, affords adequate precision, performance and life expectancy for most "upper range" commercial-grade applications.



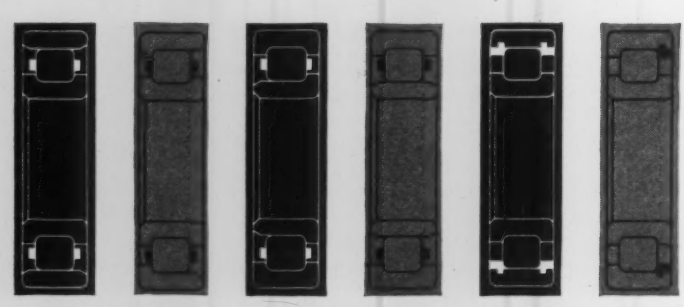
E-B Separable Inner Race

L-J Separable Inner Race

U-B Non-separable Bearing

U-J Non-separable Bearing

L-B Separable Bearing



UR-E Separable Outer Race

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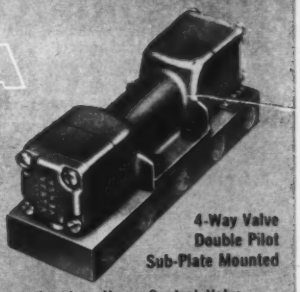

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problem solved by:

to improve operation of a pipe-mounted valve

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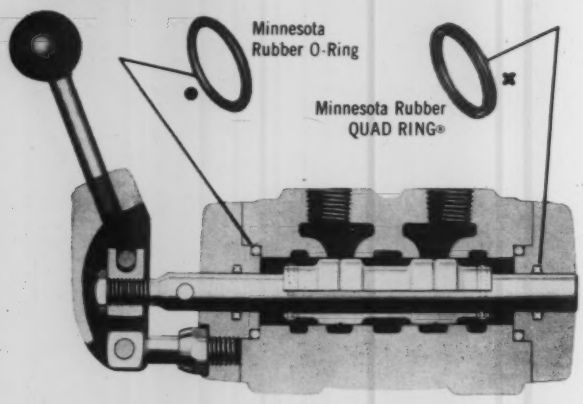

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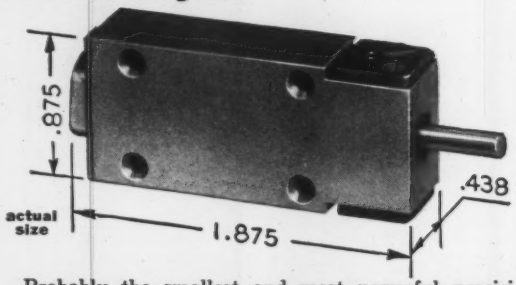

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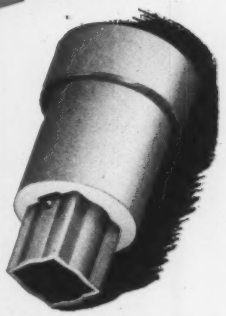

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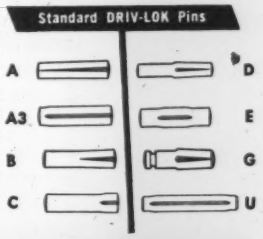

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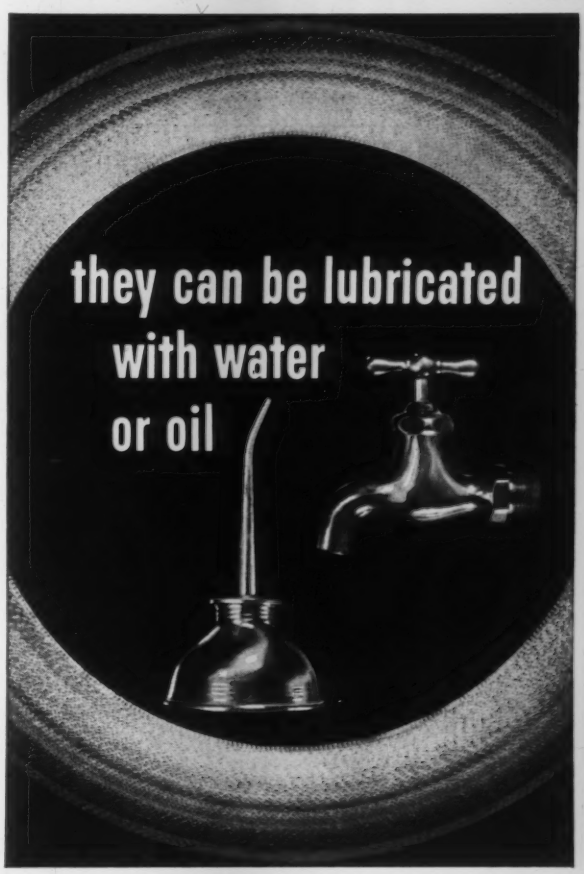

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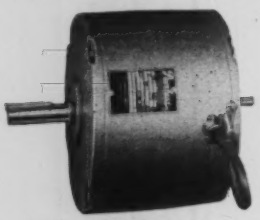

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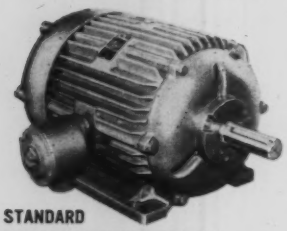

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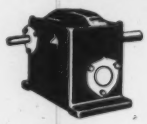

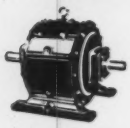

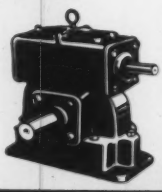

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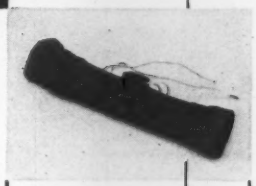

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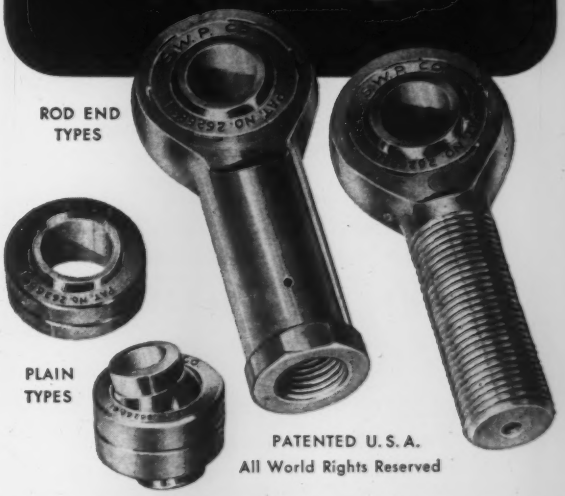

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BPA NBP

Cancer can't strike me, I'm hiding.

What I don't know won't hurt me.

Cancer?

Lots of people die of it, I know . . . but the American Cancer Society says a great many deaths from cancer are NEEDLESS deaths. That's why I do what they tell me. I have an annual medical checkup however well I feel. I know the seven danger signals. And when I want sound information, I get it from my Unit of the

AMERICAN CANCER SOCIETY

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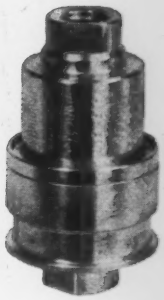
PUROLATOR FILTERS FOR THE PROTECTION OF HYDRAULIC CIRCUITS

G-200M Aircraft Restrictor Filter two-way for hydraulic oil systems metal element

PR 301 ½ GPM line type hydraulic oil filter Micronic element

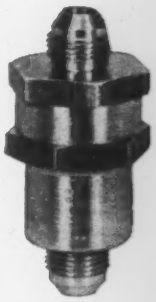


PR 362 3 CFM in-line vent type Micronic element

G 200 series in-line two-way restrictor filter Metal element, internal connections

PR 312 12 GPM line type filter Micronic element

PR 412-8 12 GPM line type filter Military approval



G-187 3 GPM in-line hydraulic oil filter Metal element

P 32-26 Low pressure, high flow hydraulic oil filter

Effective filtration is essential for optimum performance in hydraulic circuits. To keep a system clean and functioning properly, it is important that the filter be designed specifically to meet the requirements of the job.

Purolator's complete line of filters for hydraulic systems includes models for every set of operating conditions likely to be encountered. A few are shown here; there are many more standard models from which to choose. If your application requires a special filter, Purolator will design and build it. Let Purolator work on your toughest filtration problem.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

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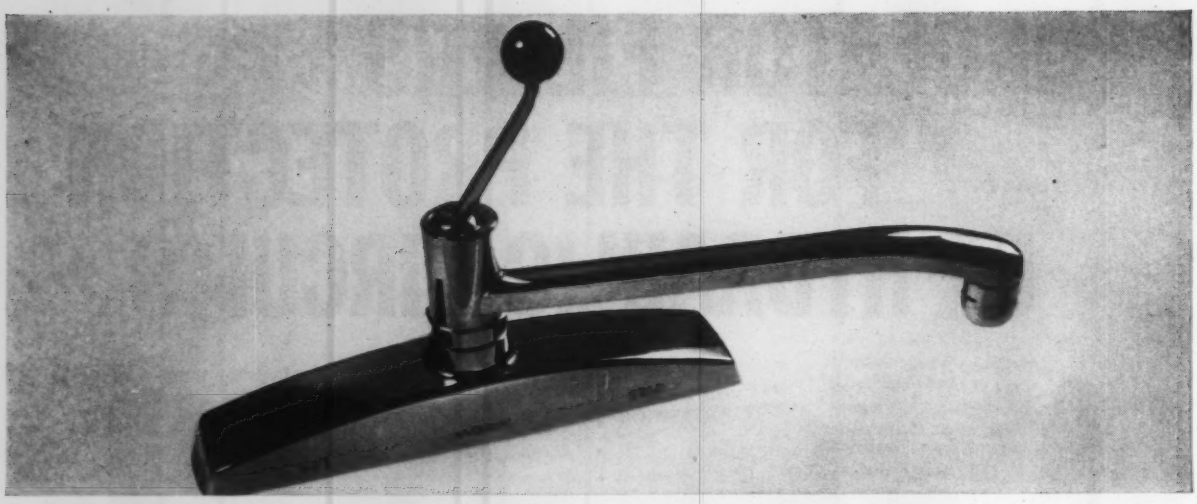
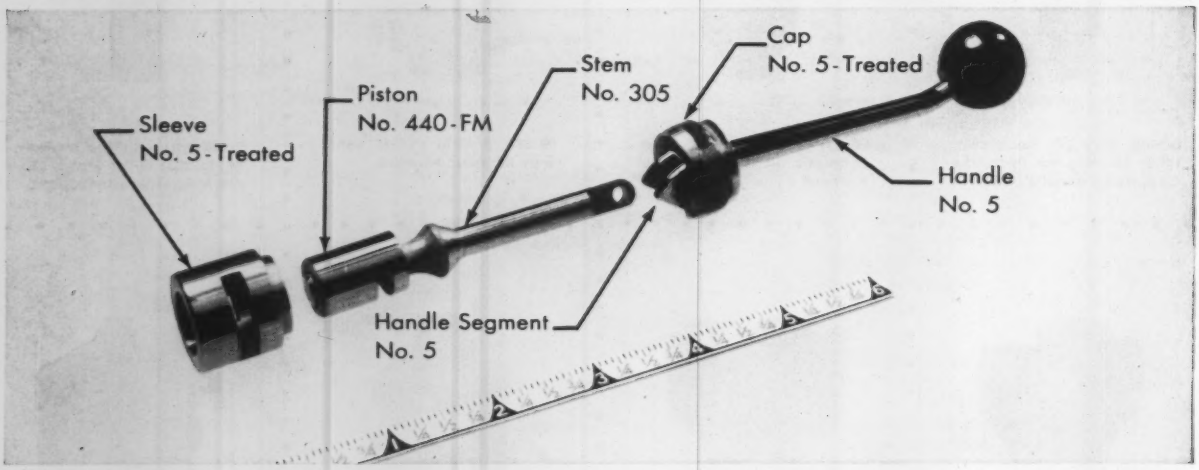


for strength, corrosion resistance and sales appeal

...it had to be Stainless



In this new one-handle mixing faucet all the important working parts are made of wear-resistant, corrosion-proof Carpenter stainless steels. Once you select stainless steel by Carpenter, you can forget about corrosion. You can design for high stresses, disregard maintenance problems, stop worrying about temperature variations and be assured that fabrication will be easy. And you not only get the help of consumer-acceptance of stainless products, but also the long experience of Carpenter. From the lab work through final production, Carpenter staffmen have the knowledge and the data. Call your Carpenter representative for the engineering information on stainless that you need. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

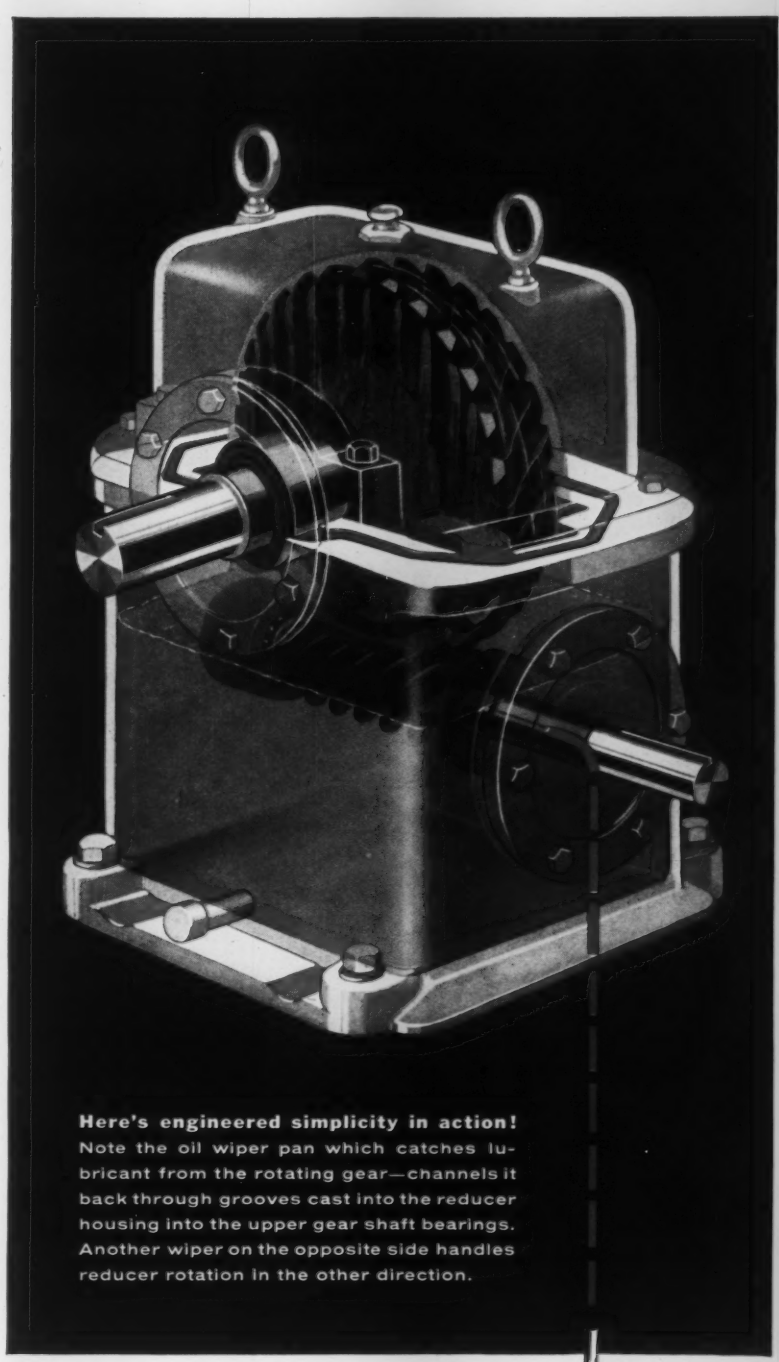
Circle 543 on Page 19

Automatic, built-in lubrication helps give Clevelands their long service life

Here's one reason why many Cleveland Worm Gear Speed Reducers have provided trouble-free operation day in-day out for over 42 years.

The secret is continuing, adequate lubrication of Cleveland's case-hardened steel worms meshing with low-friction bronze gears. If reservoir is kept filled with good, clean oil, lubrication can never fail.

To get the complete "Cleveland Story", ask for your free copy of our new Bulletin 145. The Cleveland Worm & Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.



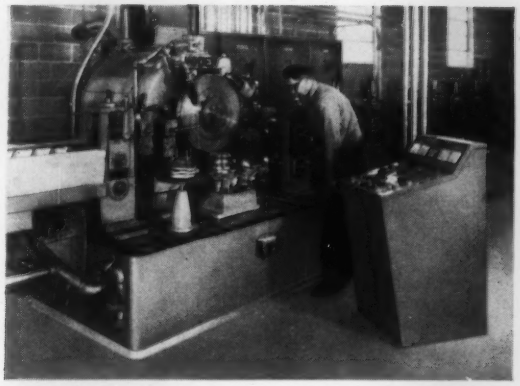
Here's engineered simplicity in action! Note the oil wiper pan which catches lubricant from the rotating gear—channels it back through grooves cast into the reducer housing into the upper gear shaft bearings. Another wiper on the opposite side handles reducer rotation in the other direction.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers

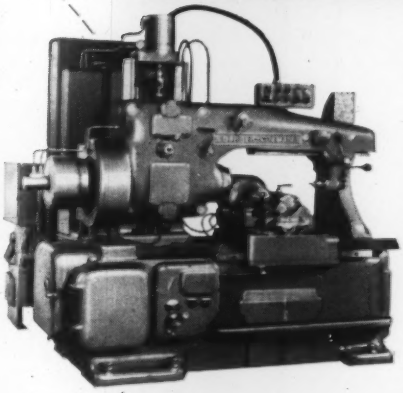
Circle 402 on Page 19

The Yoder Company uses Cutler-Hammer Motor Control. Type M electric resistance weld tube mills automatically form cold rolled steel into pipe or tubing at a rate of 35 to 150 feet per minute. Cutler-Hammer Control is provided as standard equipment.

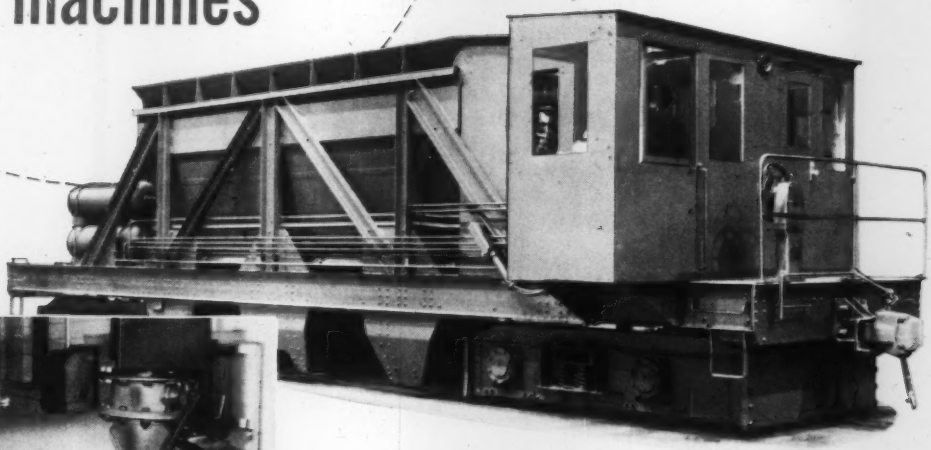


CUTLER·HAMMER
CONTROL
C·H

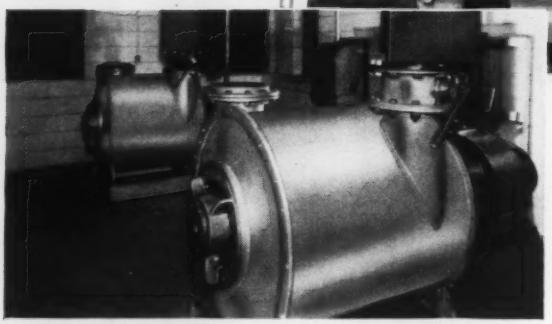
Choice of the leader's ...the mark of better machines



Barber-Colman Company uses Cutler-Hammer Motor Control. The 14-15 production hobbing machine uses Cutler-Hammer Relays as standard equipment.



The Atlas Car & Mfg. Company uses Cutler-Hammer Motor Control. 50 ton, double compartment, bottom dump ore transfer cars are equipped with Cutler-Hammer Control.



The Spencer Turbine Company uses Cutler-Hammer Motor Control. High volume centrifugal blowers provide the air supply for the aeration tanks at a new sewage plant. Cutler-Hammer Motor Control is supplied as standard equipment.

You too will find it pays to use Cutler-Hammer Motor Control; it installs easier, works better, and lasts longer. For detailed information write Dept. R243. CUTLER-HAMMER Inc., Milwaukee 1, Wisconsin.

CUTLER·HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

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